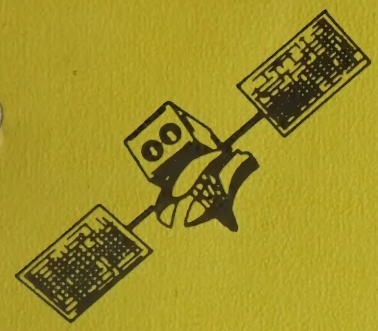

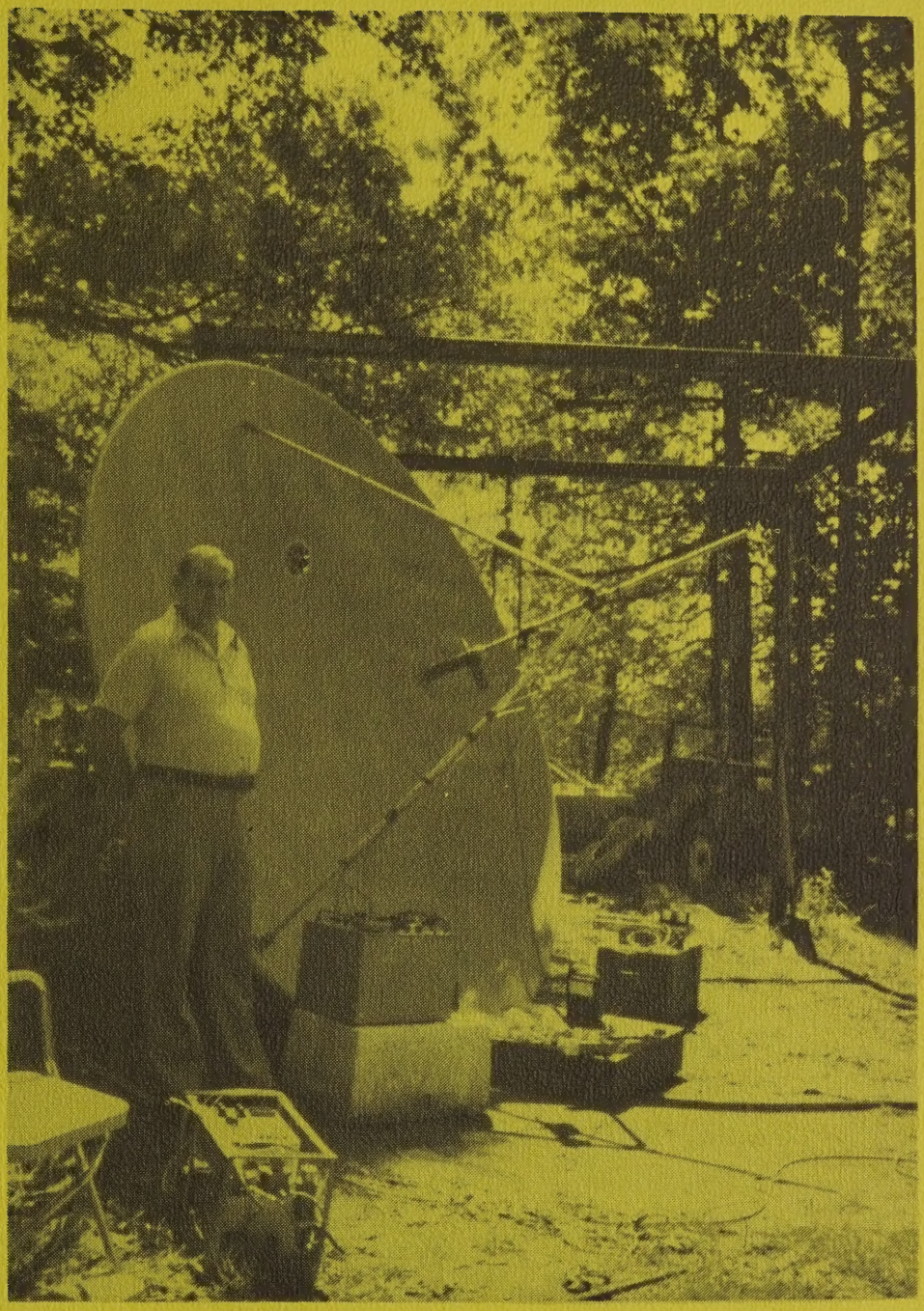

THE COLEMAN TD-2 CONVERSION

...a manual to guide you in the conversion of surplus microwave electronics to an operating satellite TV terminal.

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Satellite Television Technology
P.O. Box 2476
Napa, California 94558
and, Robert M. Coleman

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THE COLEMAN TD-2 CONVERSION MANUAL

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THE COVER - Robert M. Coleman and his 10 foot surplus parabolic antenna and TD-2 conversion low cost (as in cheap!) satellite TV receiving system.

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coleman TD-2

DOING IT CHEAP(ly)!

There is always a certain attraction to doing something for less money than you are supposed to be able to do the job for. This manual, prepared to describe the work done by Robert M. Coleman of Travelers Rest, South Carolina, illustrates just how inexpensively satellite TV reception can be.

There are of course trade offs associated with doing it 'cheap'. We'll be frank about what they are, and how they add complications to the casual viewing of the many satellite signals available.

High quality TVRO reception is possible with cheap equipment. The perfectionist will however not be satisfied with this approach for he will settle for nothing less than NTSC / NAB broadcast quality baseband video and audio.

The facts are simple enough; the biggest part of the trick is to get the elusive 4 GHz range signals down to a frequency where you feel comfortable working with the modulated envelope. That says getting it down to 70 MHz (which is a very suitable IF) as quickly as possible. With certain limitations, if you can get the 4 GHz signal down to 70 MHz in a hurry, much of what we would call 'broadcast quality video' (and audio) can be added to the circuits at or below 70 MHz.

Robert Coleman approached the home satellite TVRO project much like the telephone company approached terrestrial microwave link system design. When the telephone firms first moved into this frequency range in the late 1940's they looked at the technology then available and decided (wisely it turned out) that getting the signal out of the 4 GHz microwave region to the VHF region of 70 MHz "in a hurry" seemed like a logical design approach.

The TD-2 is nothing more than a mixer. Or to put it another way, a 'frequency converter'. You have three 'ports' on this gadget; one output and two inputs. The output is at the IF or 'intermediate frequency'. The two inputs are for the (1) 4 GHz satellite TV signals, and, (2) a local oscillator. The mixing takes place inside the TD-2 (or with any mixer) when the 4 GHz satellite TV signals are married to the local oscillator signal. When you add the local oscillator frequency to the 4 GHz satellite TV signal, you create a new signal which equals the sum of the two frequencies when added together. The same 'mixing process' occurs when two frequencies are pushed together and there is a difference be-tweeen the two frequencies.

In the case of the TD-2 (or any mixer you may elect to utilize as a substitute) the 70 MHz IF is derived when there is a difference of 70 Mhz (the IF) between the local oscillator (LO) and the 4 GHz range TVRO signal. If your TVRO signal is coming in on 3760 MHz (transponder 2 on SATCOM) and you want to mix that 3760 MHz signal with a local oscillator to obtain a 70 MHz IF, you can do it with a local oscillator operating at either 3690 Mhz (3760 minus 70 MHz) or 3830 MHz (3760 plus 70 MHz).

The TD-2 approach TVRO receiver is called a 'single conversion receiver' because the input frequency (between 3,700 and 4,200 MHz) is down converted to only one lower frequency (centered at 70 MHz) before the signal is demodulated and turned into video baseband. This is not an uncommon approach to microwave receivers, but it is not the only approach. Many commercial receivers utilize a 'double conversion' technique in which the 4 GHz range signal(s) is first converted to a "high IF" (often between 500 and 1,300 MHz) where it is amplified and filtered, before being converted a second time down to the commonly employed 70 MHz range.

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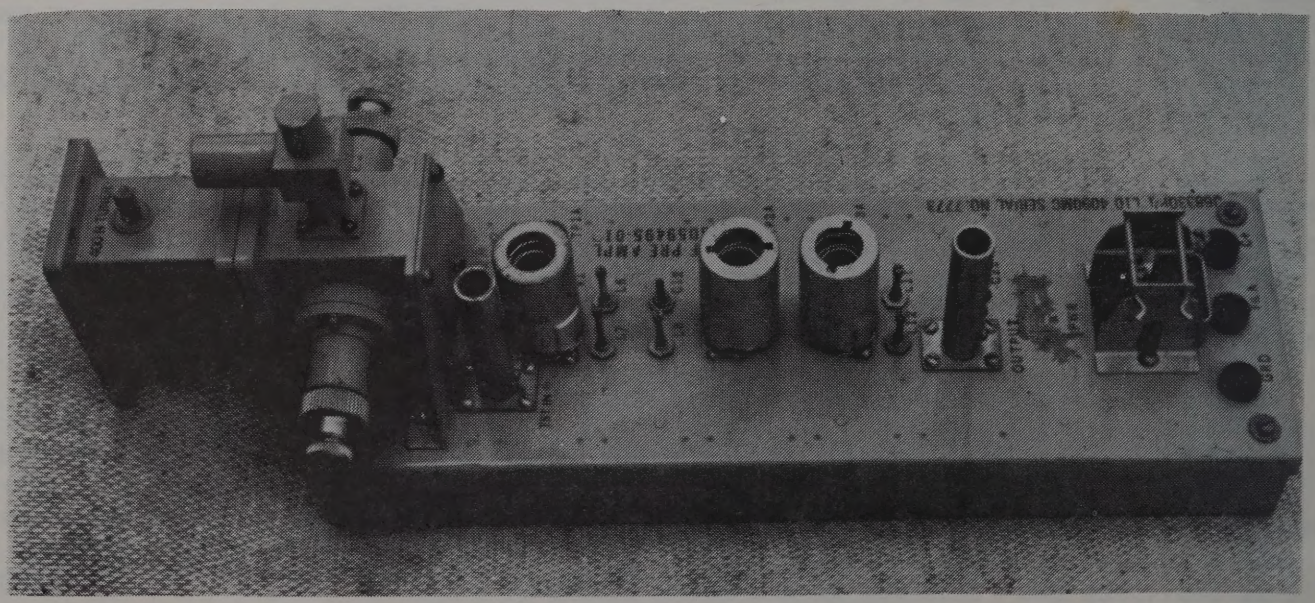
In Coleman's case, the TD-2 unit has been utilized only as a frequency converter or mixer. No other portion of the TD-2 has been utilized by Coleman; although he did utilize some of the component parts (after removing them from the TD-2 package) for the construction of other TVRO hardware.

The TD-2 may now be hard to find. Following initial publicity about the "usefulness" of the TD-2, those that were then available on the surplus market quickly disappeared. We'll look at this problem here. It is not a problem as it turns out.

The TD-2 is a module-portion of a much larger microwave receiving package. In its most common telephone company application, it mounts on a rack (one per terrestrial microwave channel). Waveguide (transmission line) comes to the TD-2 from the horn type antennas employed by the telephone firms through a signal splitting system that allows multiple channels to be 'stacked up' on one antenna. The TD-2 is currently being replaced, systematically all across the United States, by a newer system.

In the photo shown here the TD-2 is shown as a module. Note that we have an almost square type of box on the far left (this is the single channel input bandpass filter which Telco uses to separate terrestrial channels into descrete TD-2 modules), then a second box next right which has two tubular protrusions front and rear and a right-angle looking protrusion coming out of the top. This segment is the piece of interest; this is the mixer portion of the TD-2 module. Following this, again to the right, we have three tube shields (on the tubes in the photo) and a pair of smaller tubes which are the input and output test and operational fittings. These three tubes are most often 417-A type tubes which in their day were considered good quality (i.e. low noise) small signal amplifiers. These are operating as received with a 70 MHz center frequency. In other words, this is a 70 MHz IF.

One of the reasons Telco is getting rid of these TD-2 modules is that they are expanding the 'channel capacity' of the terrestrial microwave links. Telco looks at each of the TD-2 modules and determines what in that module is restricting the number of 'telephone channel' signals which can be moved through the unit. Frequently the band-



THIS IS IT - a complete TD-2 surplus unit. Left side, input bandpass filter; next right (just left of tubes) is the important part; the mixer head. Three tubes to right are 417A i.f. amplifiers working at 70 MHz. Most people throw the 417A section away since it suffers from too-narrow-passband and not adequate gain.

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width of the 417-A stages of IF amplification are the 'limiting' factor; these stages simply cannot be expanded to cover the desired 55 to 85 MHz bandwidth (30 megahertz wide) and still retain sufficent 'gain' to function as required. There is a message here about using the 417-A series of three 70 MHz IF stages that you may find with your own TD-2 module; that being that chances are excellent you won't get adequate bandwidth nor gain from this IF chain. We'll come back to that shortly.

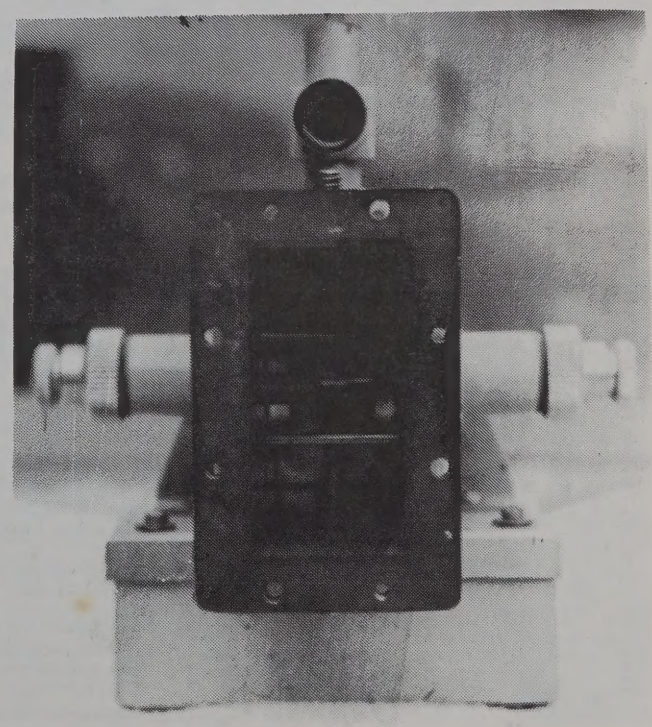
Another reason Telco is getting rid of the TD-2 units is noise figure performance. Telco depends upon certain signal to noise ratios, through the 4 GHz to 70 MHz down-conversion, to equal the channel loading sensitivity they require. On some very heavily loaded Telco trunk routes the TD-2 units have been retrofitted with something called an S-Bar Pre-Amp. This device (marked 68387P/ List 1 or 2; LNA 652A (WE)) is a signal (pre) amplifier which has been tacked into the system ahead of the input filter. The S-Bar Pre-Amp's also may be marked as 'Circuit Interrogator' devices. These were interim devices brought out many years ago by Telco to improve the noise figure performance of a TD-2 'bay' of equipment. They typically have 28 dB of gain and in the current modernization program some of these are being taken out and 'surplused' as well. They are useful as 4 GHz amplifiers although you will still need a low noise (bi-polar or GaAs-FET) section ahead of them. They are typically broadband covering the full 3.7 to 4.2 GHz region.

Another Telco effort to improve the noise figure performance was to remove the 417A amplifier stages and to replace these with solid state (i.e. transistorized) amplifiers. These units, typically having a California Microwave label plate, are usually broadbanded over 55 to 85 MHz (or more) and they may have enough gain to act as about half of the IF gain you require for satellite TV reception (in the IF portion).

NOW - how do you locate all of this 'fine' equipment? And what portion of it do you really need to build a 'cheap' TVRO receiving system?

The telephone company apparently has no hard rules about what is done with 'surplused' gear. In many cases it is up to the descretion of the engineer who is in charge of making the change outs what is done with the various 'bits and pieces' that are removed from service. Larger Telco parts are disposed of 'through channels'; that typically means through some regional marshalling-out-yard. A very small portion of this gear ends up in normal 'surplus channels'; meaning it does not end up at Fair Radio Sales (Ohio) or at other firms that 'specialize' in used, old equipment trading. Most of this gear ends up in small shops, on a local basis, having moved from the telephone engineer responsible for replacing the gear to a local friend, a local ham or to some local radio-TV-electronic gear emporium.

You find this equipment by making a trip to the local telephone company engineering office and arranging to meet the local engineer who is responsible for maintaining the 4 GHz microwave systems in the area. He will know if in your area the upgrading of the TD-2 program is started, underway or finished. He will know if



TD-2 MOUTH-ON - This is the input end on most TD-2 units you will find on the surplus market. That's an input bandpass filter (the rods create tuning) and you throw that away unless you want single channel reception!

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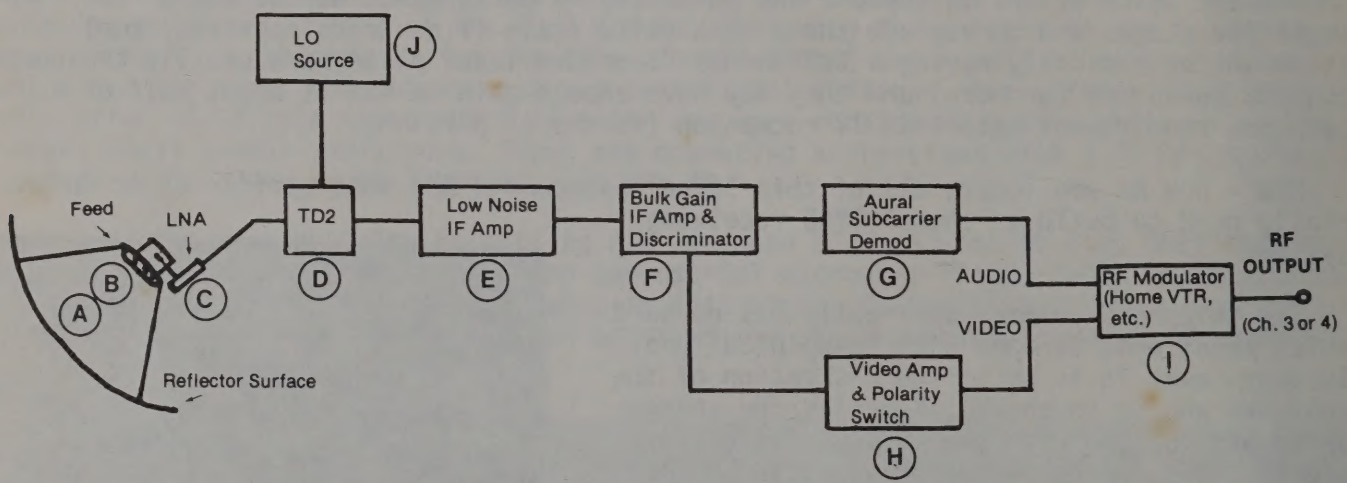
equipment is currently available, or will be, and 'how' to get it.

NOW - suppose you cannot find any TD-2 equipment. Are there alternate approaches?

Remember that the useful portion of the TD-2 is really just the 4 GHz to 70 MHz mixer head. The rest requires major surgery and even at that maynot be capable of quality reception. So what we are really looking for is a 4 GHz to 70 MHz mixer.

From The Howard Terminal Manual (available from Satellite Television Technology) we learn that the VARI-L Corporation (3883 Monaco Parkway, Denver, Colorado 80297) currently sells a mixer device called the DBM-500. This mixer is used by Taylor Howard for his 4 GHz to 1.2 GHz first conversion and again for his 1.2 GHz to 70 MHz second conversion (the Howard receiver is of course double conversion). The price on this mixer is in the $75 region (although logic suggests it will drop soon). There are other mixers available (Watkins-Johnson, etc. labels) and what you are looking for is a mixer that functions beyond 4,200 MHz (4.2 GHz) with a conversion loss in the

COLEMAN TD-2 CONVERSION TERMINAL



ELEMENTS OF COLEMAN TD-2 CONVERSION SYSTEM

A) - Ten foot (or larger) reflector surface (found **surplus** for $100 to $500)

B) - Birkill Hybird Mode Feed; home constructed for $10 to $15 (see appendix)

C) - Low Noise Amplifier, bi-polar from Hewlett Packard Applications Note # 967 (see appendix) with three stages minimum, or Coleman HFET series GaAs-FET stages (two stages minimum) as described in this Manual.

D) TD-2 GHz to 70 MHz mixer (frequency converter) (found **surplus** for $5 to $25)

E) Low Noise (under 2 dB noise figure) 70 MHz IF amplifier (+/- 10 MHz at under 1 dB gain variation/ripple); Coleman uses surplus RCA CATV/MATV amplifier. 12 to 20 dB gain recommended as minimum.

F) IF Amplifier; 70 MHz center frequency, recommended +/- 10 MHz passband with 1 dB ripple or less, 40 to 50 dB minimum gain. Colernan uses Collins 220A5, a **surplus** tube-era IF strip that also has a built-in discriminator (for demodulating waveform). Similar Units available as Motorola, Lenkurt, etc. (surplus). Typical cost $5 to $25.

G) Aural sub-carrier demodulator (tuned to either 6.8 or 6.2 MHz). Coleman utilizes **surplus** Collins SC100C unit but builder could substitute HEP 6062P/CA3065 plus LM 380 audio card directly from Howard Terminal system. Surplus cost $5 to $30.

H) Single stage video amplifier and polarity switch; built by Coleman, typical cost $5.

I) TV channel (re)modulator, such as National LM 1889 'chip device' (see Howard Terminal) or use audio and video baseband from receiver to loop through and drive modulator found in home VCR unit (this is Coleman's approach since he already had a home VCR unit).

J) Local oscillator source, tuneable over range 3.630 to 4.120 GHz. Coleman uses **surplus** Hewlett Packard TS-403 or similar unit (typical cost $25) although Avantek VTO 8360 VCO will also do job for slightly more money using current device (see Howard Terminal Manual).

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7 to 10 dB region (less conversion loss or noise figure is desireable). The VARI-L DBM-500 mixer will cost you more probably than you would pay for a TD-2 module, but it already has SMA/OSM fittings on it, it is already to plug into the system and operate and the performance will be measureably better than the TD-2 in most cases.

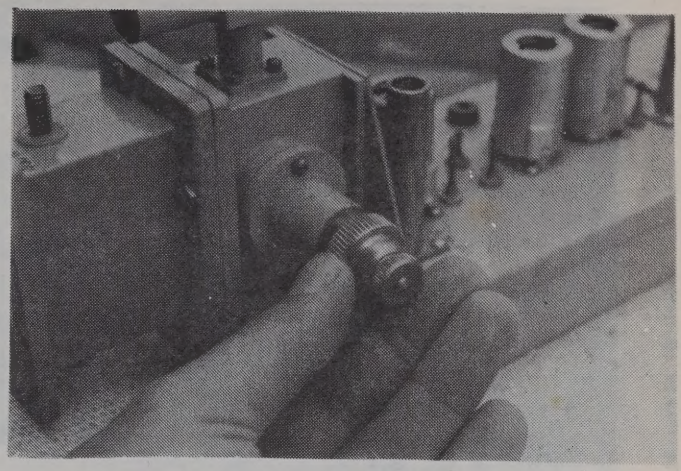
If you have a TD-2 or do locate one (do not give up easily; they are around!) the next job is to understand what it is you have to do next.

On the page to the left we see the basic Coleman TD-2 Conversion System. As this system developed for Robert Coleman, he found that there was really not very much actual construction required to get pictures; it was primarily a job of locating the proper type of pre-built (i.e. surplus) modules and plugging them all together. You should understand the following:

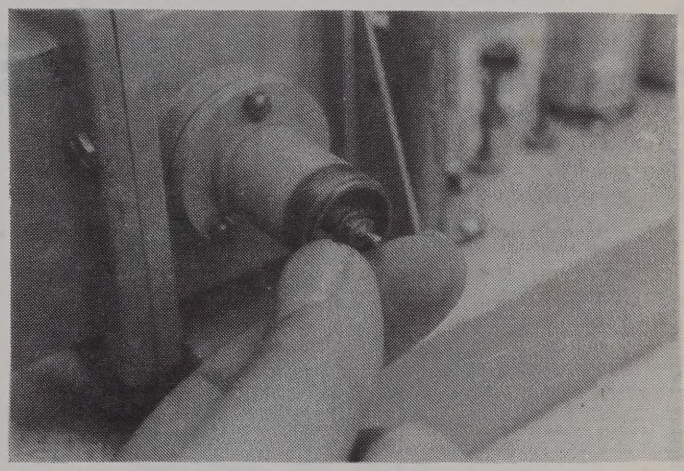
> No single module specified is critical. There are numerous subtitutes for every module shown, either from surplus areas or by building your own module from scratch (out of the Howard Terminal Manual for example) if you run out of leads for surplus equipment.

We mention this early-on to insure that you do not get discouraged when you are unable to locate a specific module. You may well end up with a 'hybrid' terminal; one made up partly of surplus modules and partly from modules you have constructed. We are sure you are considering the Coleman TD-2 approach because you want to save big dollars in building your own terminal. And the purpose of this manual is to give you sufficent understanding of each module to allow you to do just that.

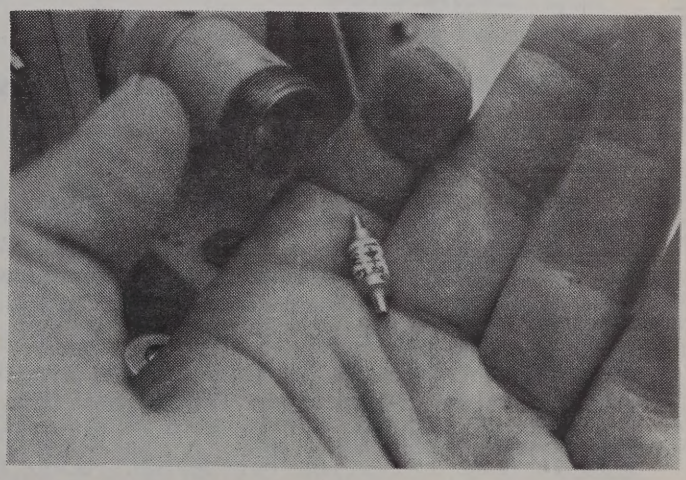
There are two Coleman-created portions to this terminal. Neither are essential to receiving TVRO pictures. The LNA (low noise amplifier) is detailed in this manual in several forms including the Steve Birkill bi-polar LNA and the Coleman GaAs-FET LNA. As you will see, you do not have to have an LNA to get pictures but you will find the picture quality vastly impro-



GETTING AT THE DIODE - unscrew the cap.



THERE'S A DIODE - one half of the mixer circuit in the TD-2 downconverter.



THE DIODE DE-MOUNTED - diode comes out of container for test or exchange.

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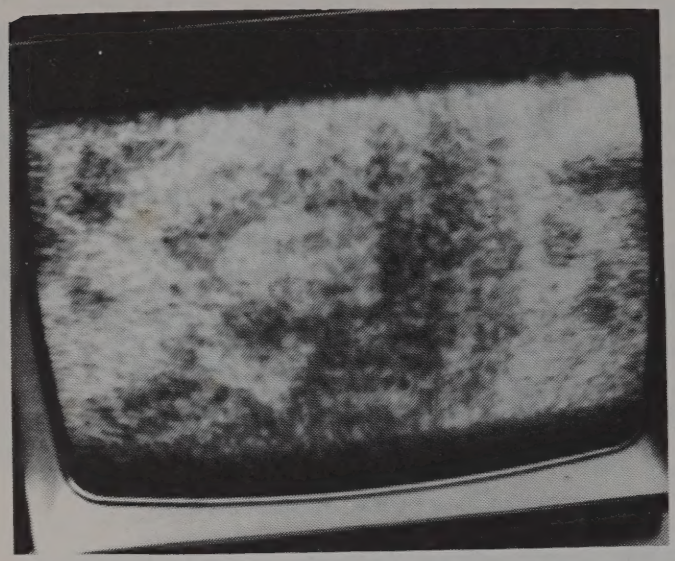
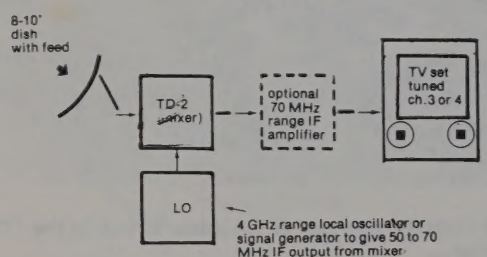


NO LNA PIX - A ten foot dish with Birkill (modified) feed into a TD-2 mixer and the balance of the surplus system described, withOUT an LNA produces a faint but recognizeable picture from SATCOM F1 in South Carolina.

QUICK TEST SET UP

With a suitable 8 to 10 reflector, a TD-2 (or other substitute) mixer, an LO source to drive the mixer, and a standard TV reciever you can 'test' for the presence of the satellite TV signals!


8-10' dish with feed
TD-2 (mixer)
optional 70 MHz range IF amplifier
TV set tuned ch.3 or 4
LO
4 GHz range local oscillator or signal generator to give 50 to 70 MHz IF output from mixer

The pictures tuned in with this no-LNA, no demodulation equipment simple system will at best be difficult to 'lock up'. There will be no sound. However, you can test a system with this simple equipment and you will know if you have a signal!

ved with an LNA. An example appears here. Let's discuss that for a minute.

If you take a suitable (8 to 10 foot) reflector surface, connect the output of the feed antenna to a TD-2 (or substitute) mixer and the output of the mixer (at 70 MHz) to an IF amplifier and discriminator, you will have satellite TV. Without an LNA and without any fancy electronics. The picture quality will not be good (see left) but it will be a picture.

There is an even easier approach. Take the reflector and a feed and the TD-2 mixer (with local oscillator) and down convert the 4 GHz signal to 70 MHz. This places the TD-2 mixer output in standard TV channel 4. Feed that 70 MHz output from the TD-2 either directly into a TV receiver (this is how Coleman first tested for signal) or go through a TV signal booster for TV channel 4 (or a broadband unit) to give some gain at the IF; and then to the TV receiver.

Again, the picture quality will be poor; in fact because the video is FM and the TV receiver is AM, it will 'lock up' only occasionally and then probably only on 'static' video displays such as color bar patterns. There will be no audio. BUT - you will have sufficent signal to prove that the antenna plus feed plus mixer works and to peak those portions of the system.

Neither of these approaches will give you pictures you will sit and watch for very long; you'd probably have a tough time telling 'Smokey from 'The Bandit' with either system although Sally Fields would probably be easily identified

THE REFLECTOR SURFACE

Robert Coleman has had no difficulty located 8 and 10 foot reflector surfaces for his experimentation. Again, they are 'surplus' and you find them by getting close to people who work in the microwave business. Who are such people? Well, they are Telco engineers, local broadcast station engineers, local CATV (cable TV) company engineers. They are the disposal personnel at local military bases where U.S. government hardware is released to the public from time to time. There are other approaches available. In a separate manual from Satellite Television Technology Oliver Swan describes a series of 'Spherical Reflector' antennas which in the 9 foot by 9 foot (billboard style) form will provide high quality home reception for perhaps $300 in materials and 25 hours of your time (see reference section of this manual for ordering instructions on the Swan Spherical TVRO Antenna Manual). John Kinik of Kintech Technology Services (1080 Ticonderoga Drive, Sunnyvale, Ca. 94087) has 12 and 16 foot all aluminum, polar mount, antenna 'kits' available. And Jim Vines of Paraframe R and D (P.O. Box 423, Monee, Il. 60449) has similar kits for various types of 12 to 16 foot antennas. Firms such as Andrew (10500 W. 153rd

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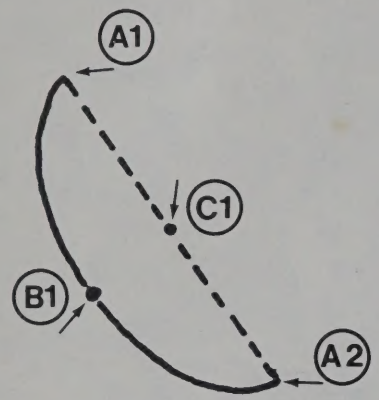
SELECTING A REFLECTOR SURFACE

1) The reflector surface should be 10' or larger (measure A1 to A2)

A



2) Focal Length should be in the 0.35 to 0.55 region with 0.4 to 0.5 best performance compromise
3) Calculate focal length by measuring A1 to B1 and then C1 to B1. The focal length is equal to:

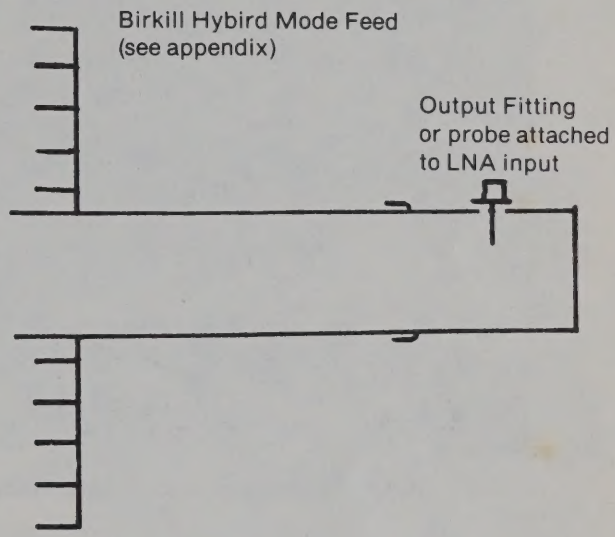
$$FL = \frac{(A1 \text{ to } B1)2}{4(x)\ B1 \text{ to } C1}$$

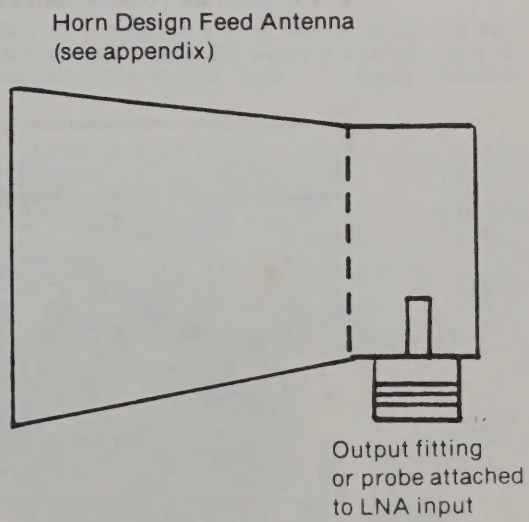
St., Orland Park, Il. 60462) and Anixter-Mark (5439 W. Fargo Av., Skokie, Il. 60076) have 8, 10 and 12 foot reflectors available new. You can purchase the reflector surfaces only from these firms and assemble your own feed and mount on your own.

If you are tempted by a surplus reflector, look closely at the (A) diagram above. Note that you calculate the focal length using the simple formula (radius squared divided by 4 times the measured depth). This should come out in the .35 to .5 number region. If it does not, stay clear of the dish unless you have the ability to design a custom feed. If the 'dish' is not round, but is oblong, it is not a parabolic reflector; it is a microwave device alright but of no value for this service.

ANTENNA FEED OPTIONS

B





Then there is the feed. The Taylor Howard manual describes a simple horn feed which can be constructed on your kitchen table. Coleman built the Birkill Hybrid Mode Feed out of the February 1979 issue of CATJ and this data is in the appendix section of this manual. One advantage to the Birkill feed is that it can be tuned for both linear (vertical or horizontal) or circular (right hand or left hand) signals; the circular polarization is used by the Intel-

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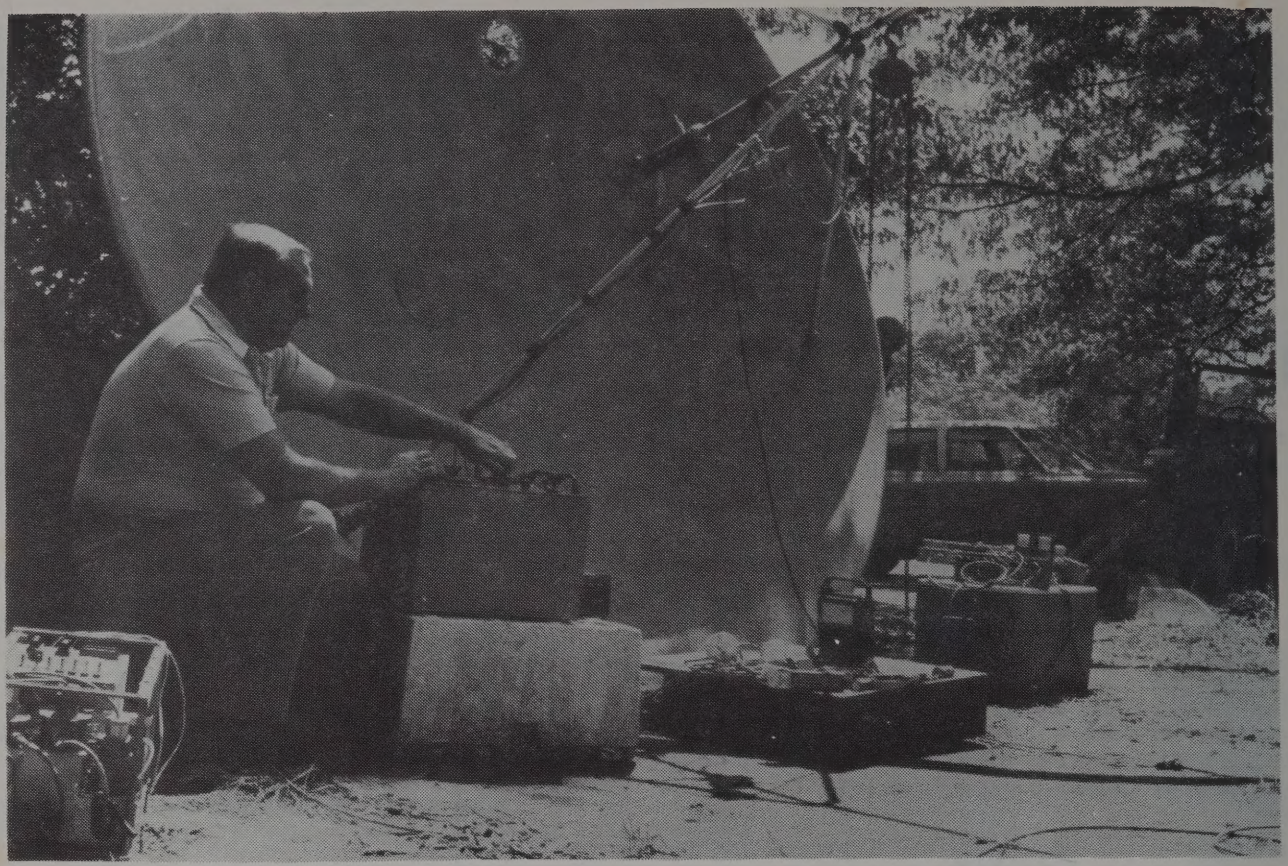
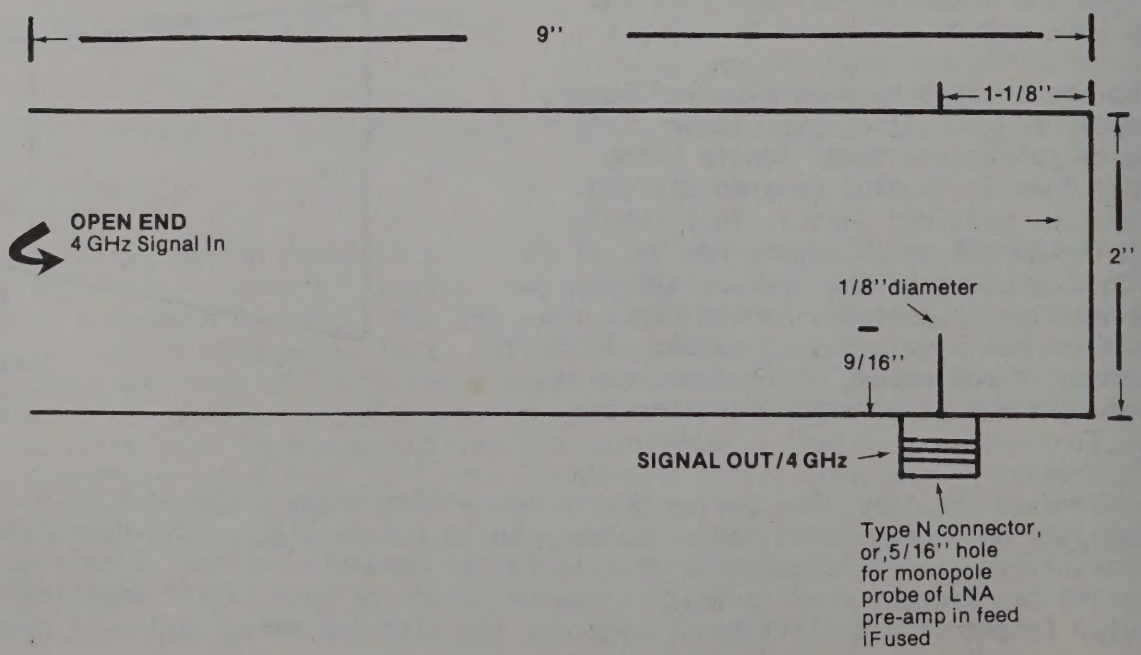


ALL OUTDOORS - the Colman Terminal ran for many months out in the open. When it rained, Bob covered it up with a plastic sheet!

9" x 2" COPPER TUBE/BIRKILL MODIFIED



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sat. If you attempt to receive the 26 dBw hemispheric level beams or the 22 dBw global beams with a dish as small as 8 to 15 feet, you can't afford to give away the 3 dB you will lose if you use a linear feed (such as the horn).

Virtually all parabolic surfaces are solid but they do not need to be. Taylor Howards 15 foot antenna uses an expanded aluminum mesh (with 1/4 x 3/8 inch holes) and the Oliver Swan 9 foot by 9 foot Spherical utilizes common aluminum window screening for the reflector surface.

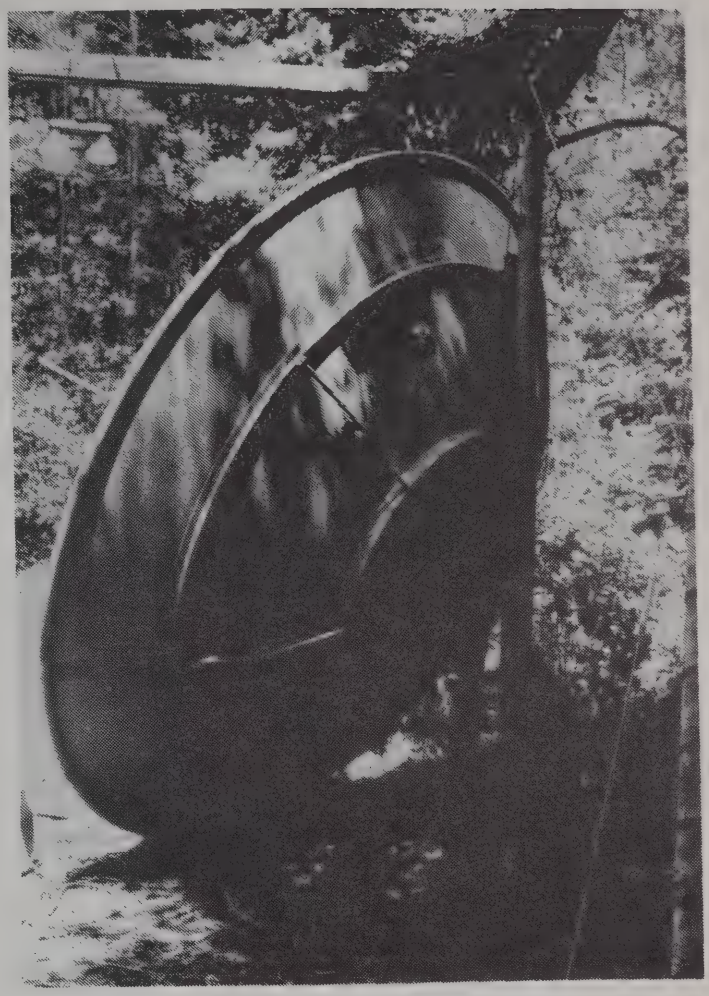
The Antenna Mount

There are many elaborate and costly ways to 'mount' the antenna reflector. Since this manual is about 'cheap' we won't dwell on them. As you can see here, Robert Coleman leans his ten foot reflector against a post in the ground. He 'stabilizes' it with some 2 x 4 materials. Yes, the antenna can rest on the ground; height buys you nothing at all but grief in figuring out a way to keep the thing in place.

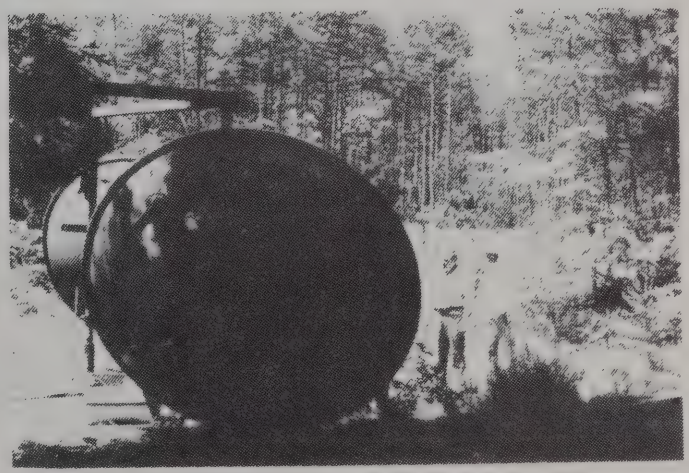
Keeping the antenna low to the ground means you can work on it easily. Since you will mount your LNA at the feed, being able to get to it to tweek and play is important.

The feed should be mounted so that you can move it in (towards the dish) and out (away from the dish) to find the optimum focal length. You should also be able to rotate the feed in a clockwise and counter clockwise fashion so that you can twist the feed antenna from linear vertical to linear horizontal polarization. This can be manual, or you could motorize this with a small DC motor.

Trees. To select a spot in the yard for the antenna, first you have to know the 'look angle' or the elevation above your horizon where the satellites sit. You can calculate this using the information found on page 23 of the March 1978 issue of QST or for $4.00 you can purchase a complete horizon to hor-



SIMPLE MOUNT - Coleman simply 'leans' his 10 foot dish up against a metal post, 'shims it' with a 2 x 4 and that's his azimuth and elevation control system in south Carolina!



HALF ACRE OF TREES GONE - tall South Carolina pine had to be cut down to provide 'clear shot' for 10 foot dish at SATCOM I.

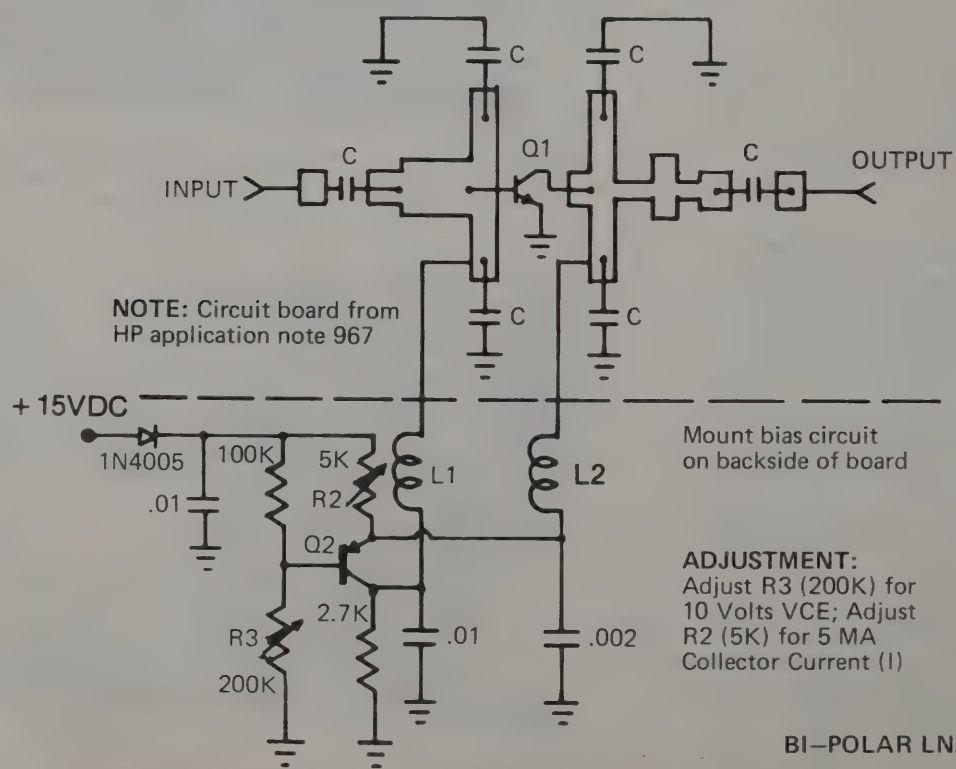
izon computer derived antenna pointing chart by ordering "Custom TVRO Antenna Pointing Chart" from CATJ Magazine, Suite 106, 4209 NW 23rd, Oklahoma City, Ok. 73107 and enclose $4 to cover costs. (*) Your antenna must not look through any trees, vegetation or buildings in its path to the satellite(s). You may have to move it around the property a little to accomplish this or do as Robert Coleman did; cut down some trees! There is no point in messing around if you have thick trees in the way; 4 GHz energy just does not like water laden trees. They soak the energy up and you can't stand even a few dB of 'additional path loss' here.

As a rule of thumb, for most central and western areas the 'look angle' is between 30 and 50 degrees up and to the southwest. The further east and north you go, the lower the look angle becomes. By the time you get into New England the look angle is starting to get down around (or below) 10 degrees. If your look angle gets too low, the ground out in front of the antenna starts looking like a (300 degree K) noise source to the antenna and smaller antennas (i.e. ten foot or less) with wider beamwidths begin having terrestrial noise problems from side lobes of the antenna at or around the 10 degree look angle area. This says you may need something larger than a ten footer in the northeast when your look angle drops to or below 10 degrees.

THE LNA (Low Noise Amplifier)

Until recently the LNA (low noise amplifier) seemed the most exotic portion of a home terminal and possibly out of touch for the average enthusiast. Fortunately this is no longer true. The tried and true basic building block, the HP # 967 Application Note, single stage amplifier appears here. Robert Coleman has found that this unit will perform with

(* - Include your geographic longitude and latitude coordinates to nearest minute.)



C =DI 6B 102 M 50P

Q1 =Hewlett Packard HXTR 6101, OR, 6102.

L1,2 =
Wind 2 turns 0.1"diameter in Q2 collector and emitter leads before inserting them through board

BI–POLAR LNA STAGE

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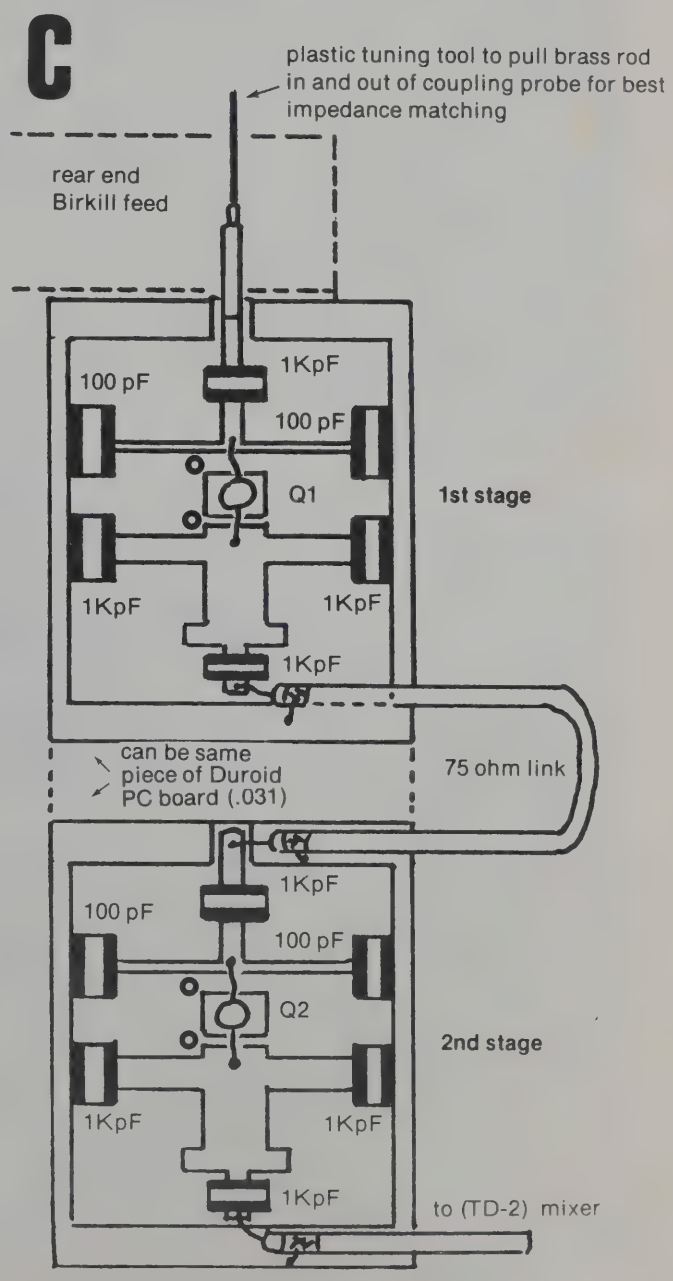
either the HP bi-polar transistor series (HXTR) or with the newer HP GaAs-FET series devices. The appendix contains additional information on the bi-polar approach as developed by Steve Birkill. We'll concentrate on Coleman's GaAs-FET (HFET 1101, 1102 and 2201) here.

The LNA mounts right at the feed antenna. Coleman's work to date has interconnected the LNA input to the feed antenna with a brass tube soldered directly onto the input to the LNA (see 'C' here). The brass tube pokes through a hole in the back of the circular waveguide (see sketch on page 8 here for modification to the Birkill feed system to accomplish this) and a smaller piece of brass fits inside of the soldered 'probe' and slides in and out within the waveguide. Coleman fitted a plastic tuning tool to the inner piece of brass and he allows the plastic tuning tool to extend through the circular waveguide to the opposite side (see drawing to right). By sliding the inner brass piece in and out but held by the brass piece soldered directly to the input to the LNA you vary the length of the probe and this allows you to optimize the impedance 'match' to the LNA and coupling between the feed and the LNA. This is the only tuning possible with the LNA; the circuit is a "build-it and turn it-on" system following the schematic, the parts layout and the photos.

THE BASIC TWO STAGE GaAs-FET LNA
(not to scale)



The HP schematic shows a single value of chip capacitors for all chips on the board. Note however that the 'C' drawing here shows 1K pF and 100 pF values. The inter-mixing of the two values was determined by experimentation by Coleman for the HFET series of GaAs-FET transistors.

A single stage of LNA amplification will not buy you much. Theory suggests that you need around 30 dB of gain to force the LNA noise figure to become the dominant noise figure in the receiving system. You can come close to this 30 dB of gain requirement with two stages of HFET but additional stages (or an additional stage) is highly recommended. The 'C' drawing to the right shows the two-stage system developed by Coleman and this package produces high quality pictures. Coleman suggests, however, that an even better system may be to use two stages of HFET followed by two stages of bi-polar amplification. A stage of HFET 1101, followed by a stage of HFET 1102, followed by two

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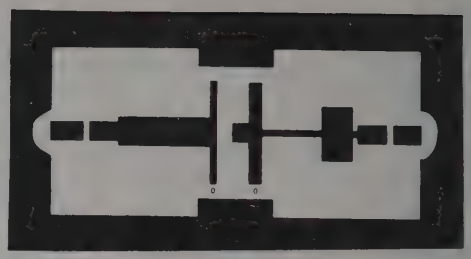
stages of bi-polar (HXTR 6101 or 6102) might be the ideal compromise between establishing a good low noise figure (in the 1.6 dB region) and having adequate gain (30+ dB) in the LNA to 'force' the LNA noise figure into the role of dominating the noise figure (temperature) for the full system.



The board layout to the right is an actual size board for a single stage of the LNA. Two stages require two of these layouts; three require three and so on. Interconnection between stages could be handled by on-single-board coupling lines but Coleman recommends that you keep each stage separate for trouble shooting purposes and to insure that you don't run into feedback and oscillation problems. As 'C' shows the inter-connection between stages recommended is simply a piece (short) of RG-59/U type (75 ohm) cable soldered into a loop.

Note on the photo appearing here that solder is 'filleted' around the full stage 'opening' on the circuit board. This practice is fairly standard at these frequencies and while it may look 'messy' it is very useful in keeping ground circuits bonded together in low ohmic paths.

The circuit board employed must be Duroid type board (available from Rogers Corporation, Box 700, Chandler, Az. 85224). This is a teflon board (.031); normal G-10

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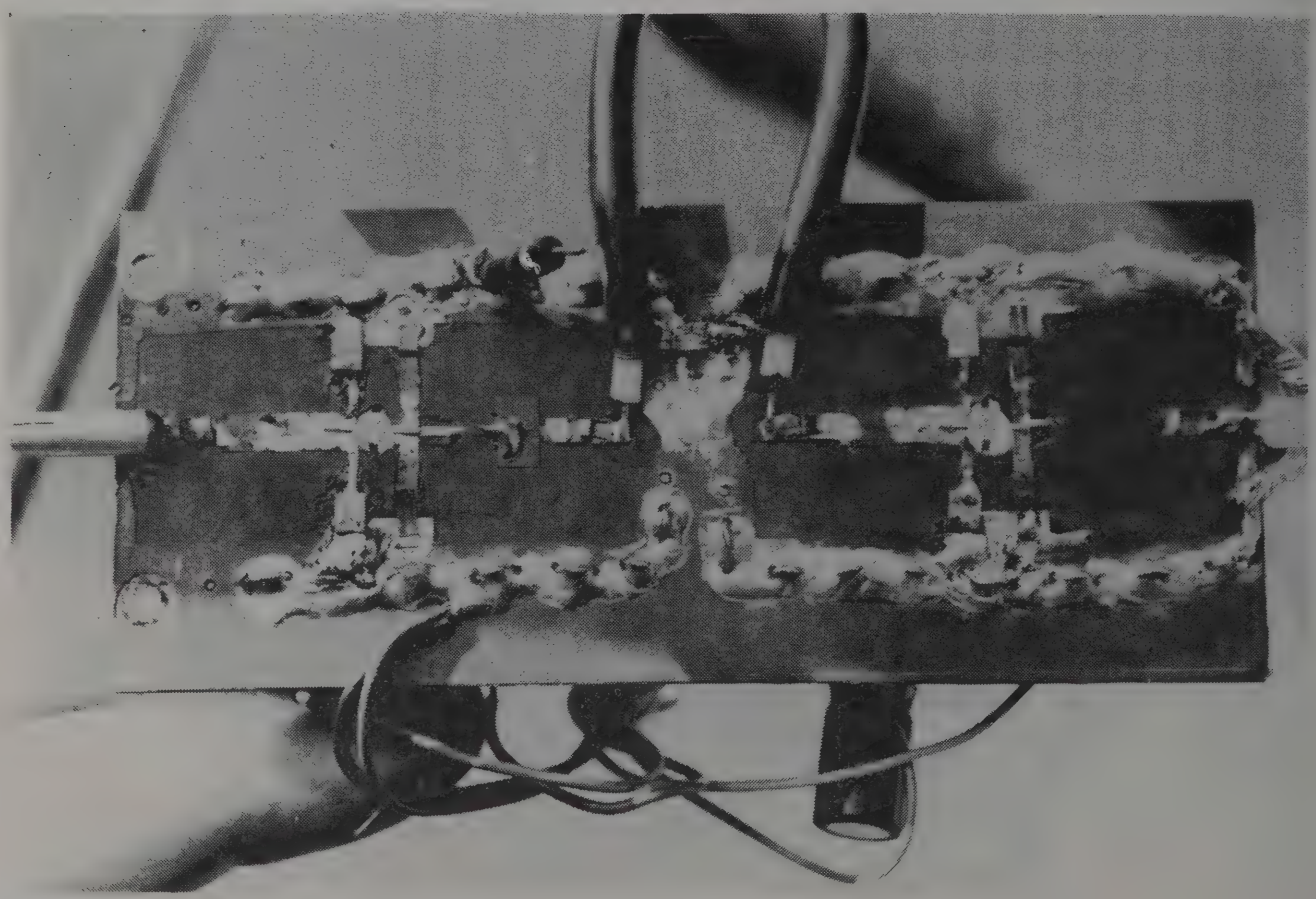

TWO STAGE LNA - with input probe (left), inter-stage coupling (coax loop) and output line (right) to mixer.

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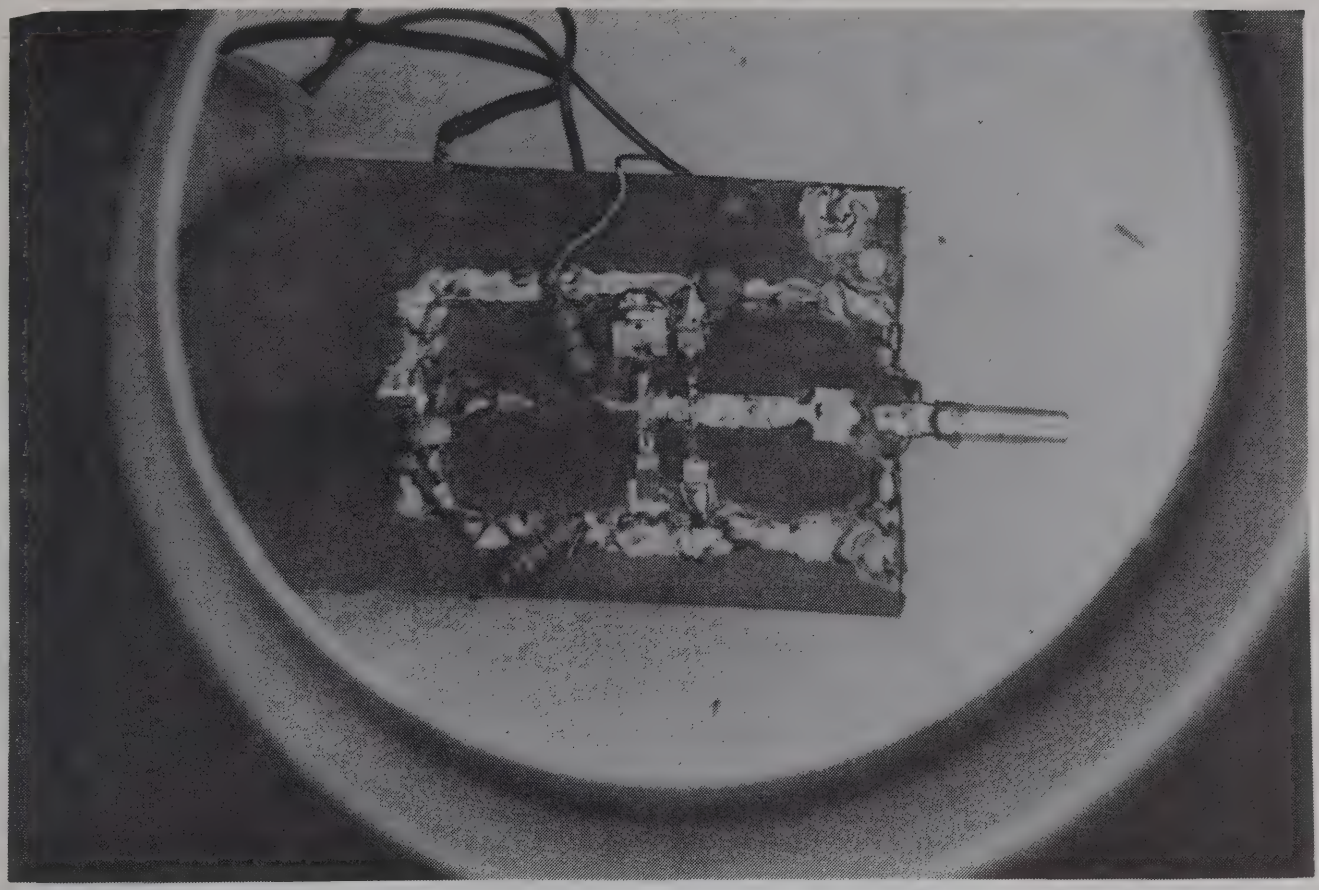
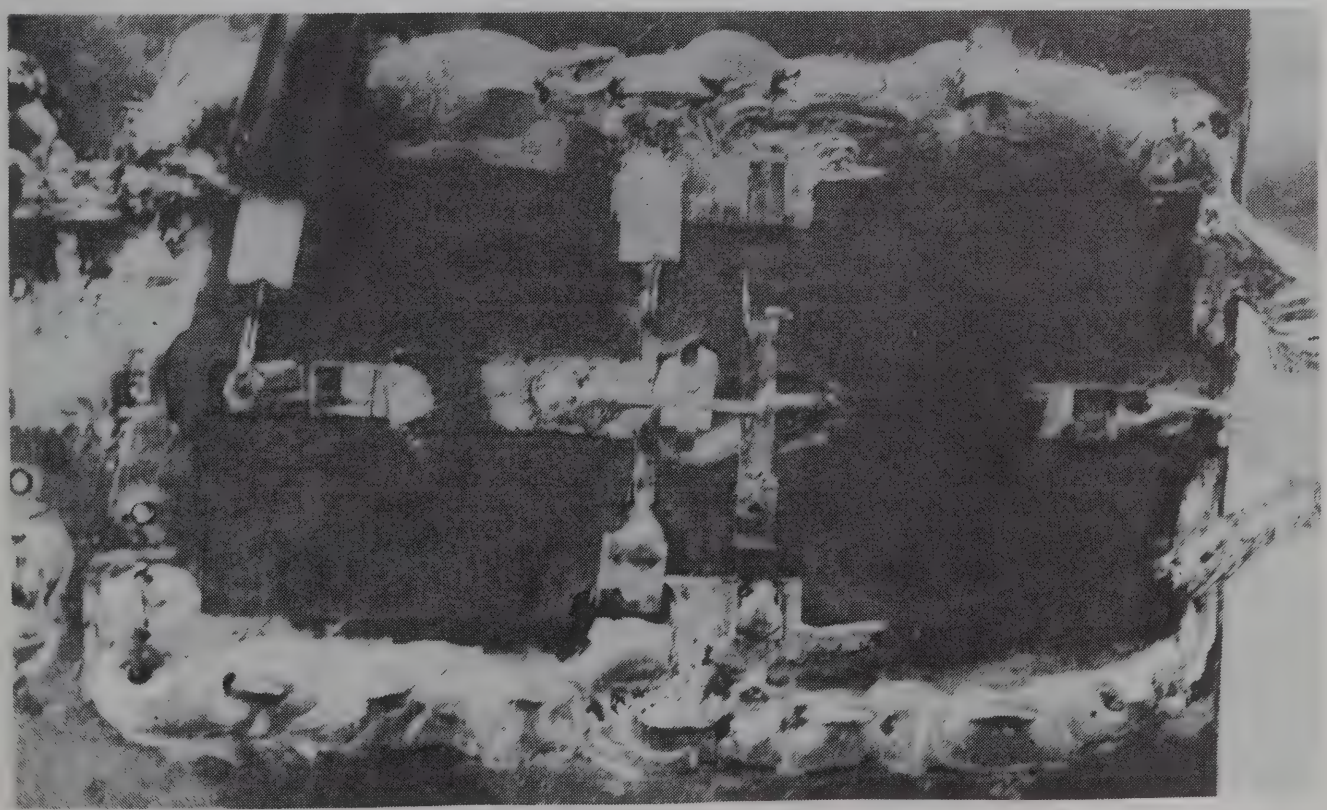


BIRD'S EYE VIEW OF LNA STAGE - parts are so tiny that when you work on unit you need magnification system and plenty of light. And breathe softly.



ONE STAGE OR THE LNA (output stage in this case). Circuit is etched on Duroid board, consists primarily of etched portions, chip bypass capacitors and GaAs-FET transistor.

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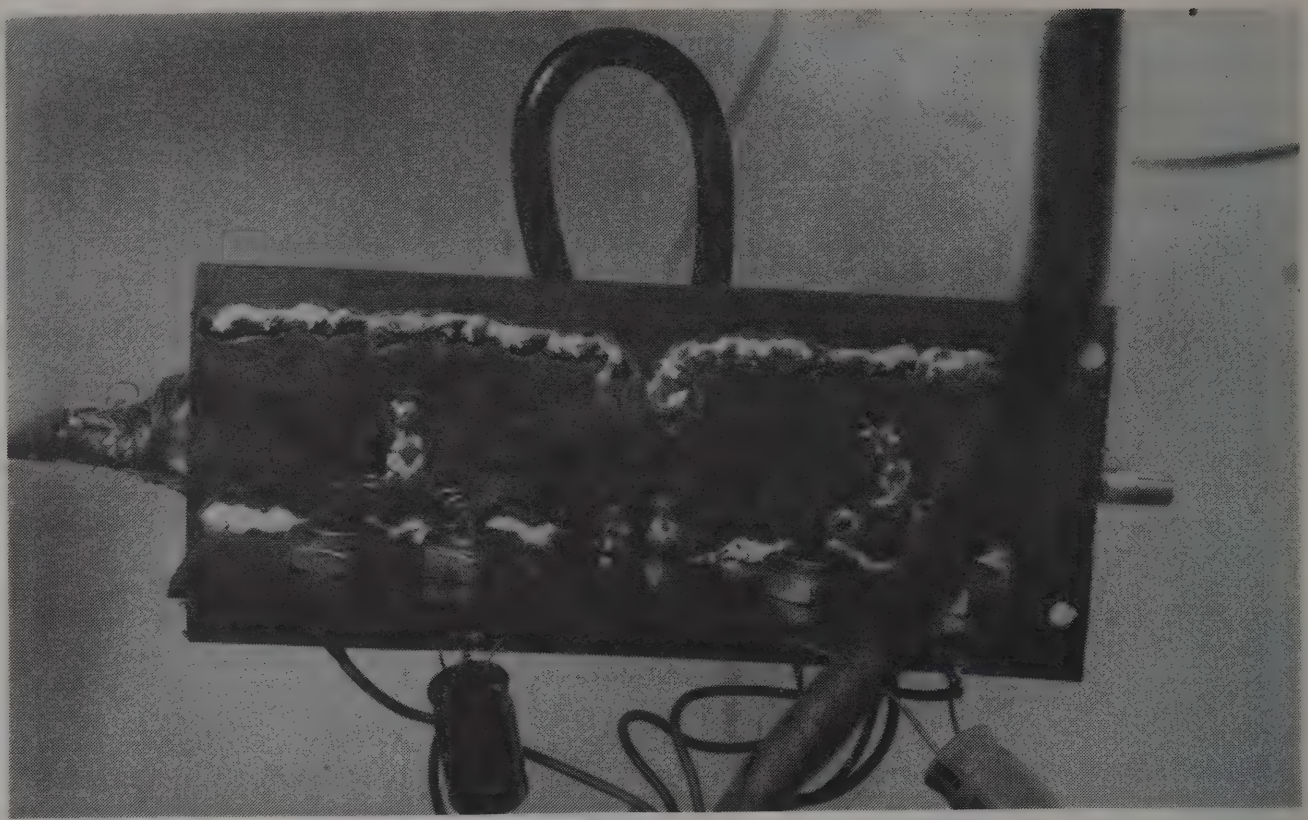
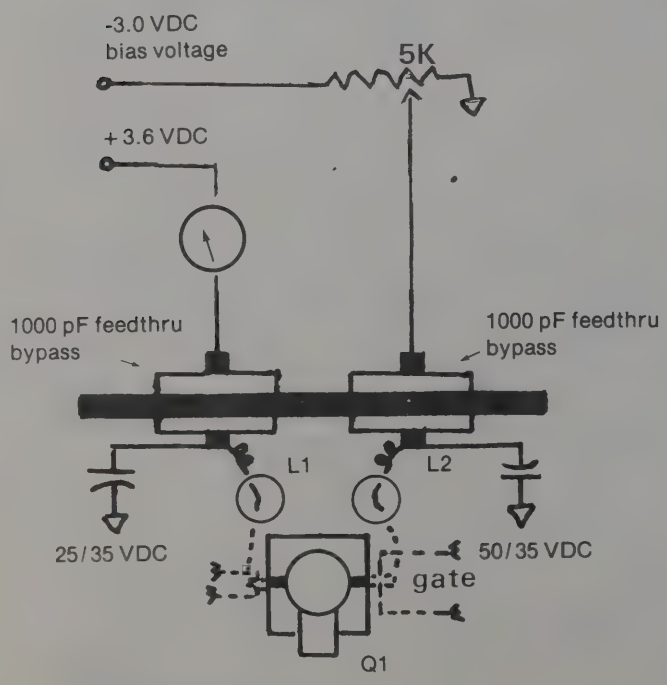
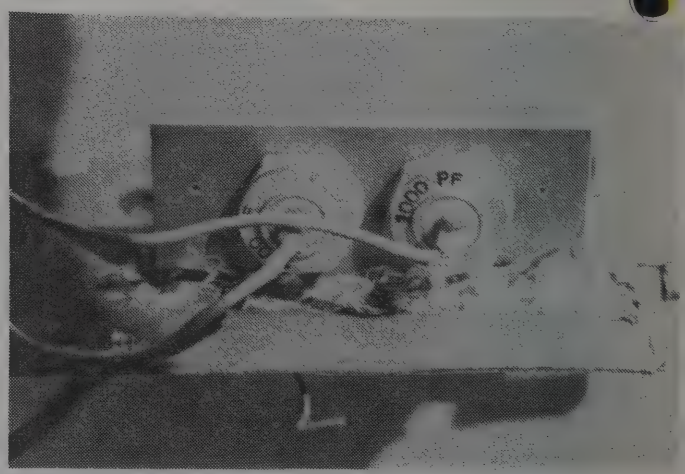


POWERING FOR LNA - back side of Duroid board with power bypassing using surplus capacitors.

LNA POWERING / BIASING CIRCUIT



L1,2 = 2 turns #36, 0.1" diameter (RF choke)



SURPLUS 1000 pF feedthrough bypass capacitors out of TD-2 transmitter go to work as component parts in Coleman two stage GaAs-FET low noise amplifier.

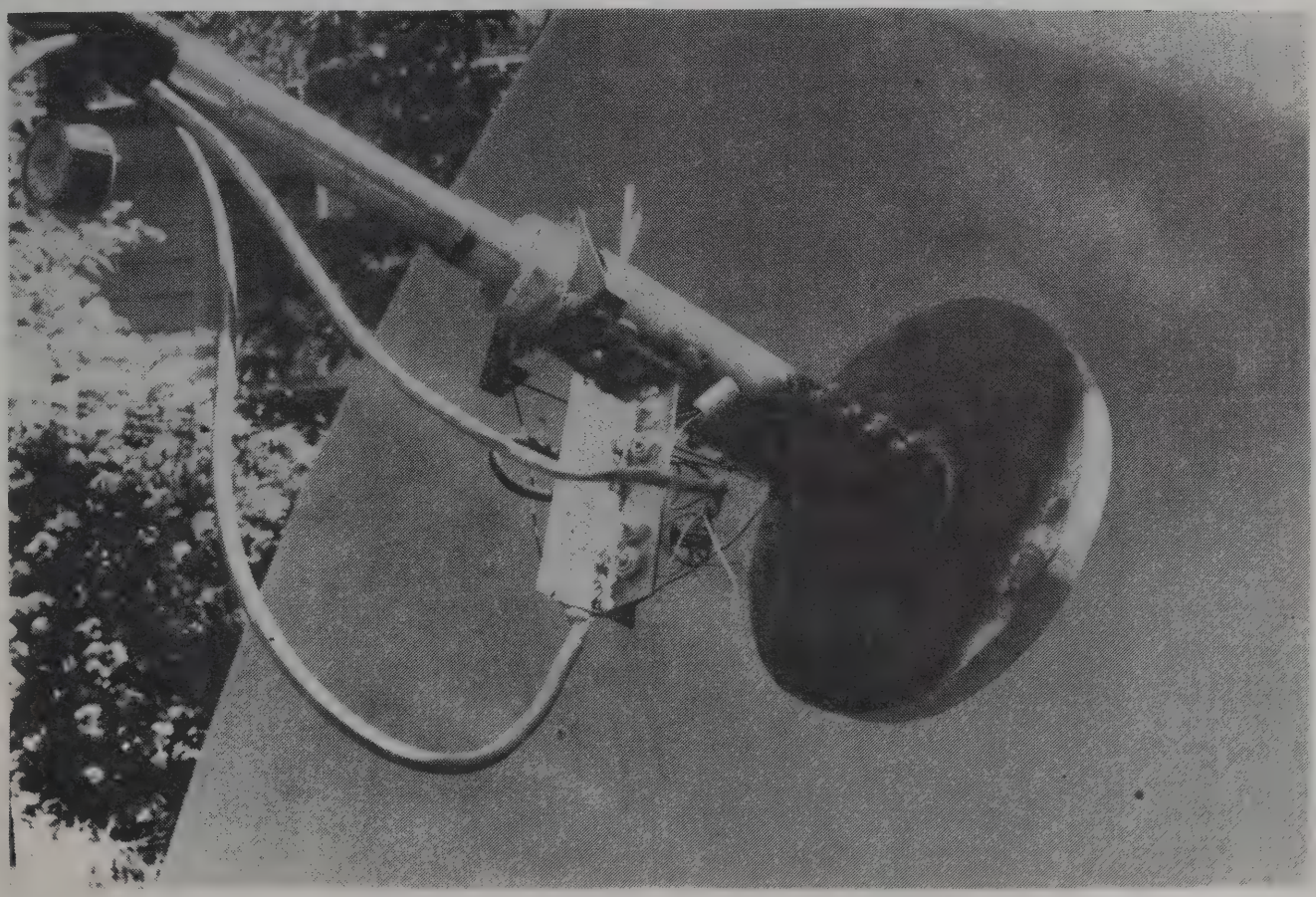
board will simply not play at 4 GHz.

The power bypassing and biasing system is shown here. Note that the bypassing is done on the opposite side of the two-sided (copper) board; mounting the 1K pF feedthru bypass capacitors on a small right-angle-mounted piece of circuit board. Those 1,000 pF feedthru bypasses came out of a TD-2 transmitter; another use for surplus!

There is no real tuning on a printed circuit (etched on board) LNA stage or stages. Everything is 'fixed' and broadband to cover the 500 MHz wide range of interest. The probe that couples RF energy out of the feed waveguide into the first stage is, as noted, adjustable in the Coleman version of the LNA since Robert found that he could greatly improve the quality of the pictures by varying the coupling (and the match) into the first stage.

Coleman's experience has shown that not all GaAs-FETs are created 'equal'. Even at the $100 price range of GaAs-FETs (these are the HFET series from Hewlett Packard) the difference from one to another, at least in the circuit shown here, can be considerable. At one point Coleman had a single stage of amplification (HFET) which was producing very high quality pictures (something that normally takes two or more stages to accomplish). This particular device was unstable (i.e. it wanted to oscillate) which leads Coleman to believe that when it was producing very high quality pictures as a single stage it was probably oscillating at a frequency well above 4 GHz and acting as a self-contained parametric pump of some sort. However, the normally broad band (i.e. full 500 MHz wide) circuit system was in this case only optimum over a couple of channels and where normally the input probe could be set and forgotten for the full band after optimizing, with this particular amplifier the probe had to be re-adjusted for optimum performance every 100 MHz or so of bandwidth change.

The HFET data sheets suggest around 4.5 volts (+) on the devices. In the circuit shown Coleman found the devices to be bordering on unstable at that voltage and he dropped the supply voltage to the +3.6 VDC specified. A bias supply line (with pot) allows you to adjust the stage(s) to the best operating performance. Ideally there should be separate bias



LNA IN PLACE - on (Birkill) Hybird Mode Feed. Plastic tuning tool protruding from top of tubular waveguide above LNA board are tuning adjustments for the probe inside of the waveguide.

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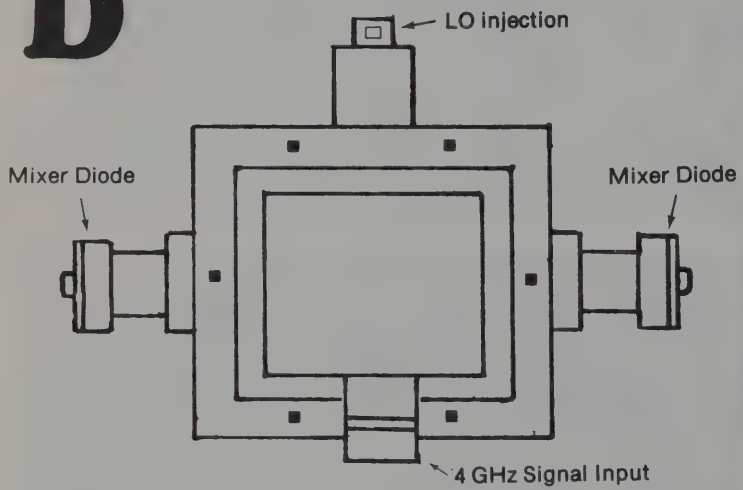
pots for each stage of the GaAs-FET amplifier since each stage is optimized individually. Maximum gain per stage occurs around 40 mA per stage but the best compromise between best noise figure and gain occurs around 12 mA per stage. It is easy to see where you are ... each stage should be metered and you keep one eye on the meter(s) and another eye on the quality of the satellite TV picture!

Parts Sources: The source for Duroid board was given on page 12. They have a minimum order in the $60 to $70 range. OR, you may purchase etched boards as follows:

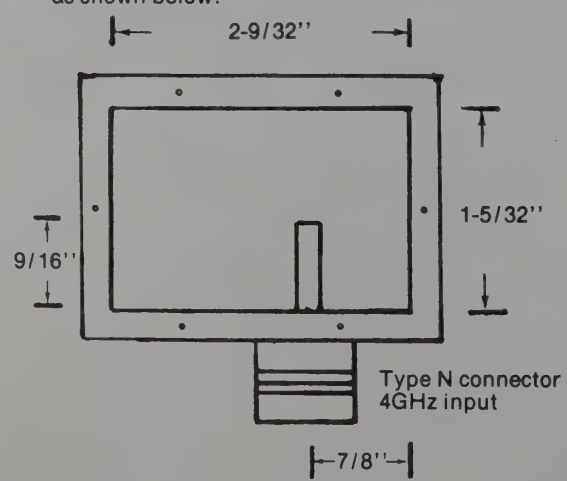
1) Board LNA-1 - a single stage of the amplifier (board layout shown on page 12) which can be utilized for either HXTR bi-polar or the HFET GaAs-FETs. Price is $12.00

2) Board LNA-2 - a two stage board for the HXTR series bi-polar transistors only. Price is $25.00.

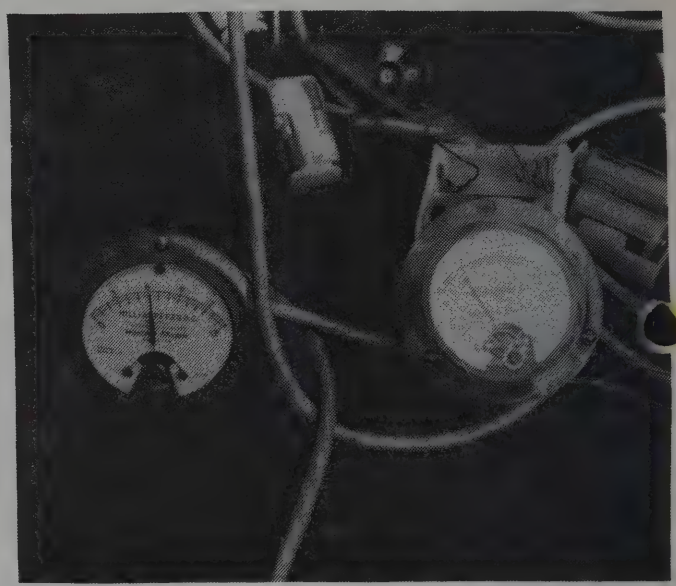
BASIC TD-2 MIXER HEAD



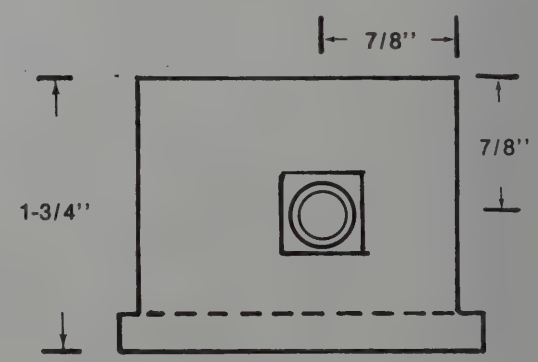
Note: If your TD-2 mixer has an input filter rather than an input 'cap' and probe, construct sealed top to replace filter as shown below.



Note: Sealed top to fit over front 'mouth opening' on TD-2 in place of rod type input band-pass filter



METERING OF LNA stages - optimum performance requires careful adjustment of operation parameters. Metering LNA provides way to extablish best looking pictures and then know where to 'go back to' when resetting the system.



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To build two stages of HFET system you will need two of the LNA-1 board. To follow this with two stages of HXTR, you'll need one of the LNA-2 board. You may order these boards directly from:

Robert M. Coleman, RFD 3, Box 58-A, Travelers Rest, S.C. 26960

3) Chip bypass capacitors - One commercial source for the 100 pF and 1K pF chip bypasses is: Dielectric Laboratories, 69 Albany St., Cazenovia, N.Y. 13035. Robert Coleman also has 'surplus' as well as 'new' chip capacitors in stock from time to time and you should contact him directly at the address given above to determine the supply at the moment.

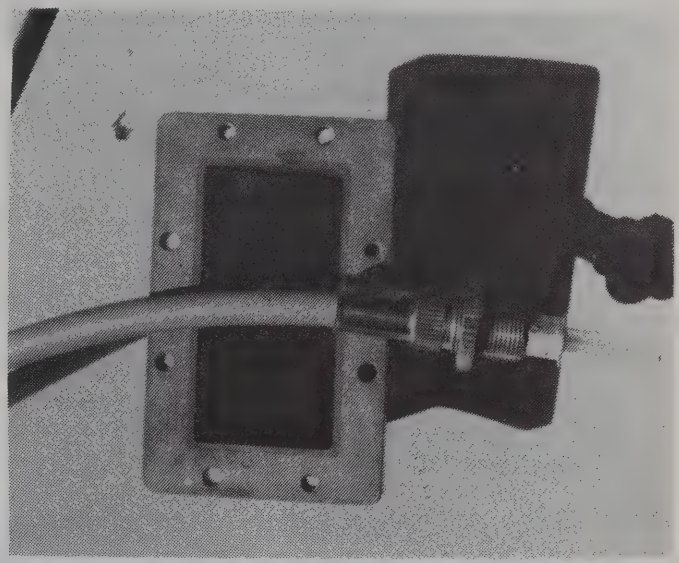
4) RF transistors - There are many Hewlett Packard sales offices scattered throughout the country. Their home office is at: 640 Page Mill Rd., Palo Alto, California 94304.

One distributor which Robert Coleman has found to be reliable is:

Hallmark Electronics Corp.
Atten: Paul Koeppen
1208 Front St., Bldg. K
Raleigh, N.C. 27609

(919-832-4465)

This particular Hallmark outlet has been able to keep a stock of HXTR as well as HFET devices in stock most of the time (until this appeared in print anyhow!).

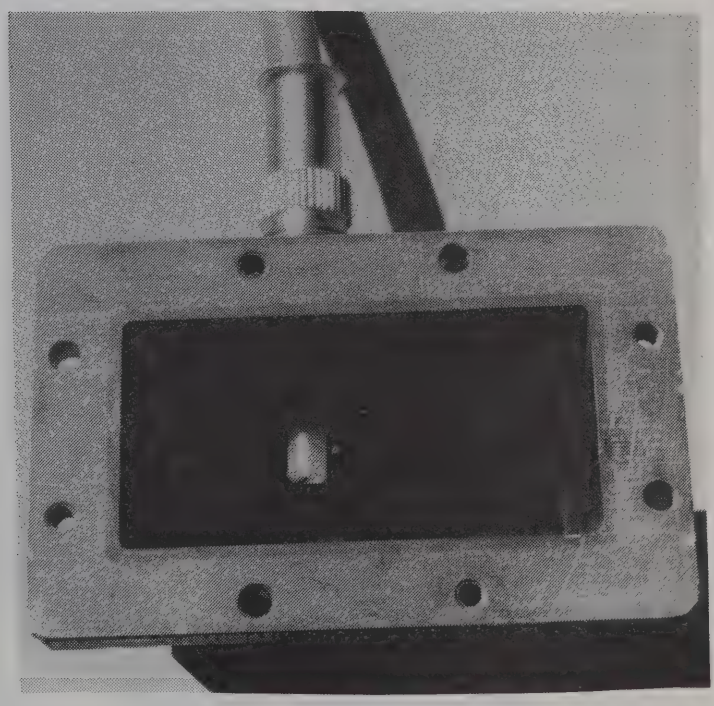


PROBE carrying 4 GHz energy into TD-2 cavity is simply piece of coax with shield cut back. See text.

THE TD-2 MIXER HEAD

The basic TD-2 mixer head may or maynot arrive at your home equipped for a feed from a piece of coax. Coleman links out of the GaAs-FET amplifier section to the TD-2 mixer head via a short (less than 18") length of 75 ohm coaxial cable. Ideally the interconnection would be fittings only - from the output of the LNA last stage to the input to the mixer head. This is not always practical however.

Most TD-2 units come with an input bandpass filter(see photo on page 3 here); a flanged device with several parallel rods through it. This should be taken off and discarded. However that leaves you with



PROBE FITTING screws into housing on cavity.

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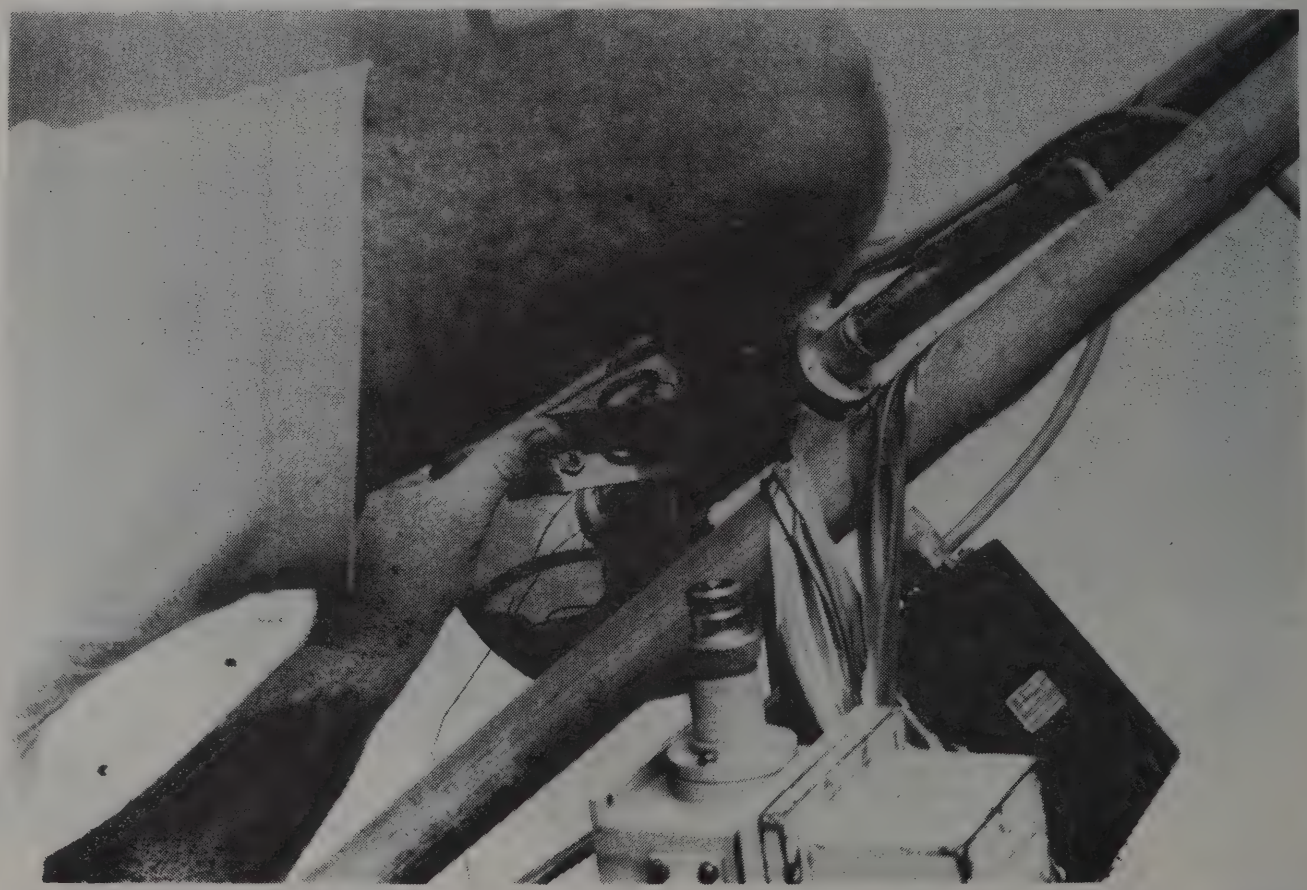
no easy way to couple into the TD-2. Obviously the 4 GHz energy has got to get in someplace!

It is possible to find original (Bell) equipment similar to that shown on page 16 and 17; a metal 'cap' that is designed to fit onto the TD-2 mixer head in place of the input bandpass filter. If you can't locate one, you will have to build it from the drawings on page 16. This is really a closed-end section of 'waveguide' into which a probe is inserted. The probe is the TD-2 end of the interconnecting coaxial cable that links the output of the LNA to the mixer. As the photos on page 17 show, this is nothing more than a length of coaxial cable (interconnecting the LNA output to the mixer) with a fitting on the TD-2 end and the shield of the coax cut back (per the drawing) so that only the (typically) white center conductor insulation (plus the center conductor copper inside) protrudes into the closed end section of waveguide. 4 GHz energy from the LNA is then 'bottled up' within the metal container and it finds its way to the mixer portion of the TD-2.

Note: If you are subtituting a VARI-L DBM500 mixer for the TD-2, you simply ignore this portion of the manual and run the coaxial link from the LNA directly into the 4 GHz input fitting on the DBM500 mixer. If constructing this cavity seems like alot of bother to you, this is one more reason to seriously consider the DBM500 as a substitute for the TD-2!

There are no other changes to make to the TD-2. The drawing on page 16 identifies the local oscillator injection port (the strange looking right-angle connector coming out of the normal 'top' of the unit).It is possible to change this Bell-type fitting out to



TAPED UP - Coleman uses Duct Tape to 'attach' the TD-2 mixer and first 70 MHz i.f. amplifier to the feed support. All of which proves being 'sanitary' is not essential at 4 GHz!.

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something more agreeable (i.e. a type N; BNC is not recommended for 4 GHz work). The output of the TD-2 (the 70 MHz range IF) comes out the bottom. If you bought a TD-2 with the three stage 417A tube type IF attached, you'll have to take the TD-2 head off of the main chassis to locate the output.

The TD-2 is beyond these instructions ready to go.

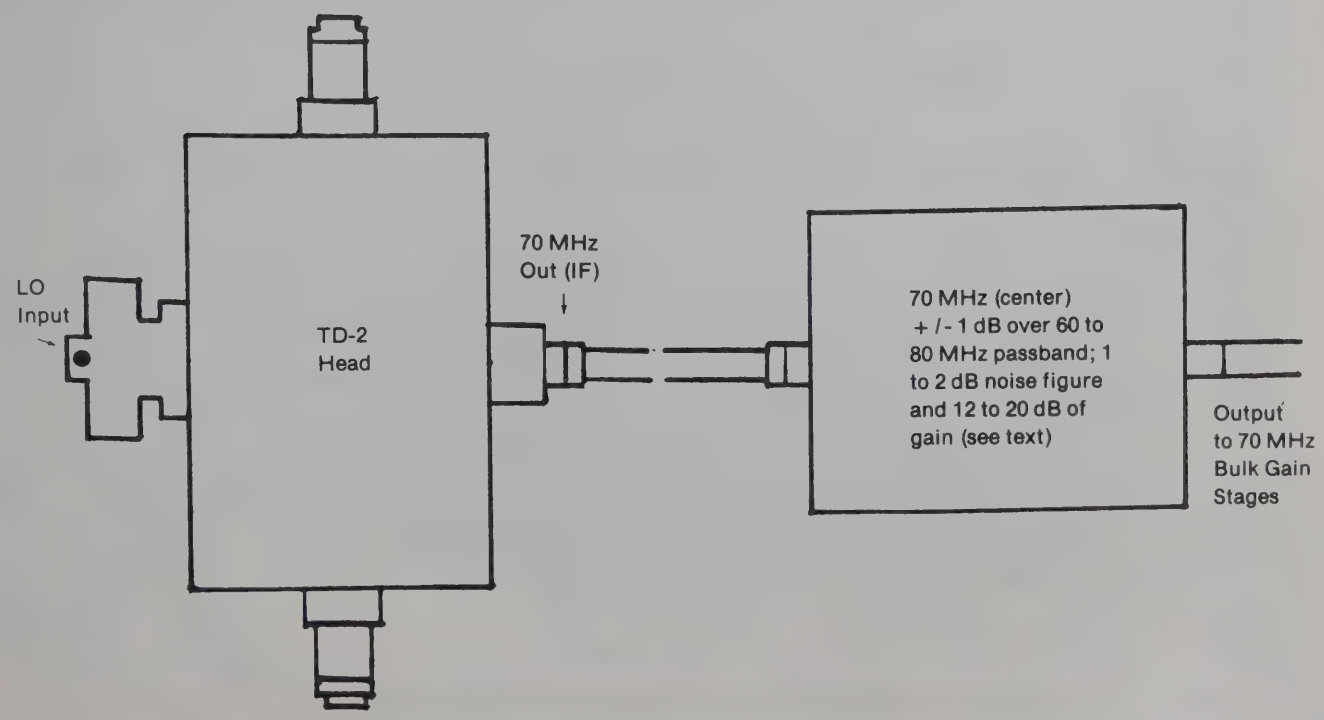
THE FIRST (Low Noise) IF

Coming out of the TD-2 at 70 MHz we are now ready to amplify the IF signal. One of the fundamental requirements is that we follow the TD-2 mixer with as low noise an IF amplifier as we can locate. In Coleman's case he located a (surplus) MATV/CATV amplifier with around 15 dB or so of gain and a noise figure (as claimed) of around 1.5 dB. What you are looking for is shown in diagram 'E' below. The amplifier should have a minimum of 12 dB of gain and up to 20 or so. It should cover the 60 (55) to 80 (85) MHz span with a flatness of +/- 0.5 dB. The noise figure should be 2.0 dB or below.

This is typically a MATV (master antenna) or CATV (community antenna/cable TV) type device. If you have a local CATV company, check there first. A 'low noise' CATV preamplifier (the type utilized at the CATV antenna for signal preamplification) will be your best bet provided it is not single channel (TV channel 4 is in the center of this range) or if it is 'single channel' the skirts on the passband are gradual enough that you are down no more than a half dB or so at the edges of the passband of interest to you (60 MHz on the low side and 80 Mhz on the high side). One source for this type of amplifier is: DAVCO, P.O. Box 861, Batesville, Arkansas 72501.

FIRST IF AMPLIFIER

E



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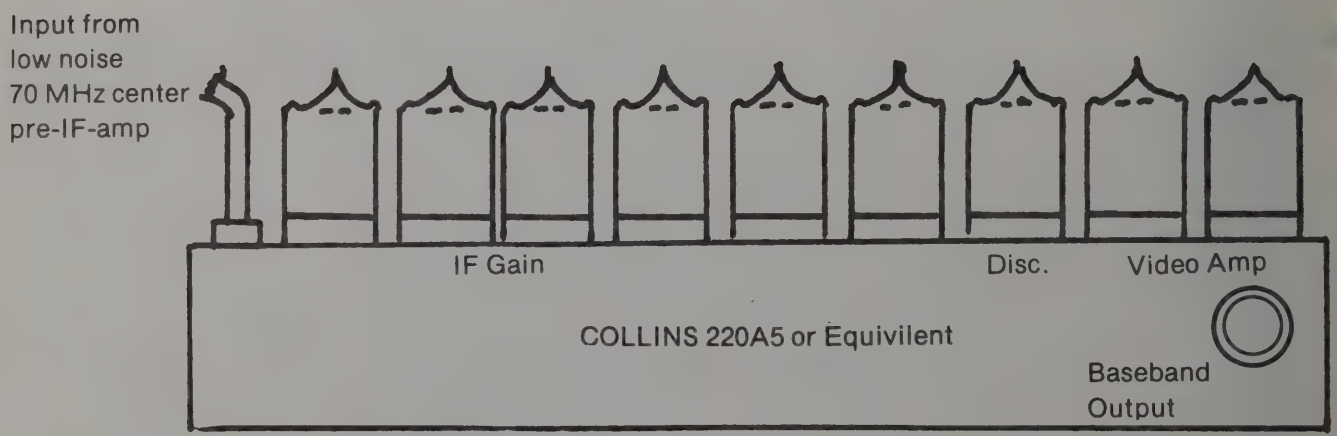
Connection to the first IF amplifier is from the TD-2 70 MHz output and standard (75 ohm) coaxial cable is used. The run should be short to the first IF amp since we have a 'noise laden' 70 MHz signal at this point and we don't want to lose any more signal level than absolutely necessary.

Hint: CATV devices you do NOT want in this application are CATV 'feeder line amp' boards, 'trunk line amp' boards or 'distribution line amp boards'. Anything that is made to amplify cable TV signals on the distribution line itself will have a noise figure that is too high for this application. On the other hand any device designed to mount at the cable TV off-air antenna to amplify the off air signals will probably be alright provided the device is not so old as to have noise figure problems (i.e. too high a noise figure). A brand new device in the $70 price range that will work fine is the Blonder Tongue CMA series pre-amplifier for 'TV low band' or the Q-BIT series antenna mounting pre-amplifier ($135 price range). Both are available from DAVCO; listed on page 19 here.

BULK GAIN IF AMP AND DISCRIMINATOR

F



Bulk Gain at 70 MHz parameters

1) Center frequency 70 MHz

2) Bandwidth + /-7.5 MHz (minimum); ideally + /-10 to 15 MHz

3) Ripple + /- 2 dB maximum

4) Gain - 40 dB absolute minimum, ideally 50 or more
5) Discriminator - adequately flat for 0-10 MHz video (+ /-)

6) Clamp - see text and diagram F1

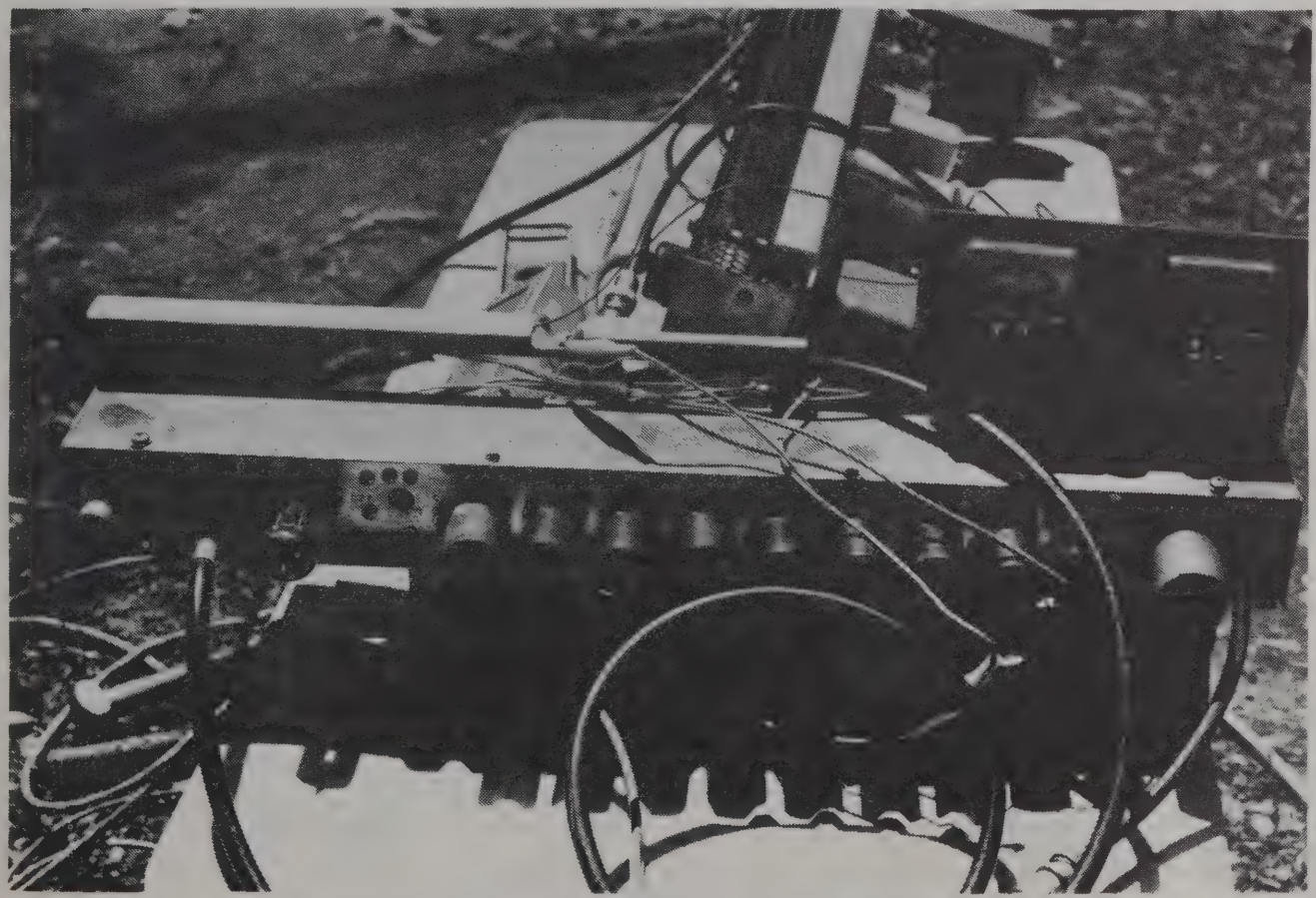
7) Video (baseband) output - 1 volt peak to peak minimum

THE (bulk) IF GAIN/DISCRIMINATOR PORTION

The primary purpose of the first (after TD-2 mixer) IF gain is to establish a good low noise figure for the TD-2 70 MHz output to 'look into'. You could build the whole IF gain string with low noise (transistor) devices but chances are you will not want to do so.

As shown in 'F' on page 20 the output from the low noise 70 MHz amplifier stage is cable coupled into a higher gain 'bulk' (as in quanity of...) stage. In the Coleman terminal this gain is provided with another piece of surplus gear; the Collins 220A5. This is a tube type 70 MHz IF strip which was originally utilized in Telco and other commercial microwave links. Units in this family, or similar units manufactured by other manufacturers, are not uncommon at Hamfests and other electronic 'Flea Markets'. Prices are usually in the $10 to $15 range. Virtually all of the tube type of 70 MHz IF strips that were once employed in commercial terrestrial microwave systems have now been replaced. In fact, many of the early solid state replacements produced for terrestrial microwave are now on the 'surplus' market as well. A good (and useable) example of this is the Collins 22E2-2MW solid state IF.

The Collins 220A5 has much more gain than is required for this task; Coleman suggests it may has as much as 100 dB at 70 MHz. Typically your 70 MHz IF 'bulk gain' requirement depends upon the amount of prior (70 Mhz) IF gain you have (in the low noise segment), plus the gain you have at 4 GHz. Overall from the first 4 GHz stage to the output of the discriminator (video detector) you need a minimum of 80 to 90 dB of circuit (voltage) gain. It cannot all be in one place of course; it needs to be spread at 4 GHz and at 70 MHz in the kind of proportions discussed in this manual. Many of the surplus 70 MHz IF strips



COLLINS 220A5 i.f. amplifier centered on 70 MHz is surplus tube type unit; includes discriminator and one stage video (baseband) amp.

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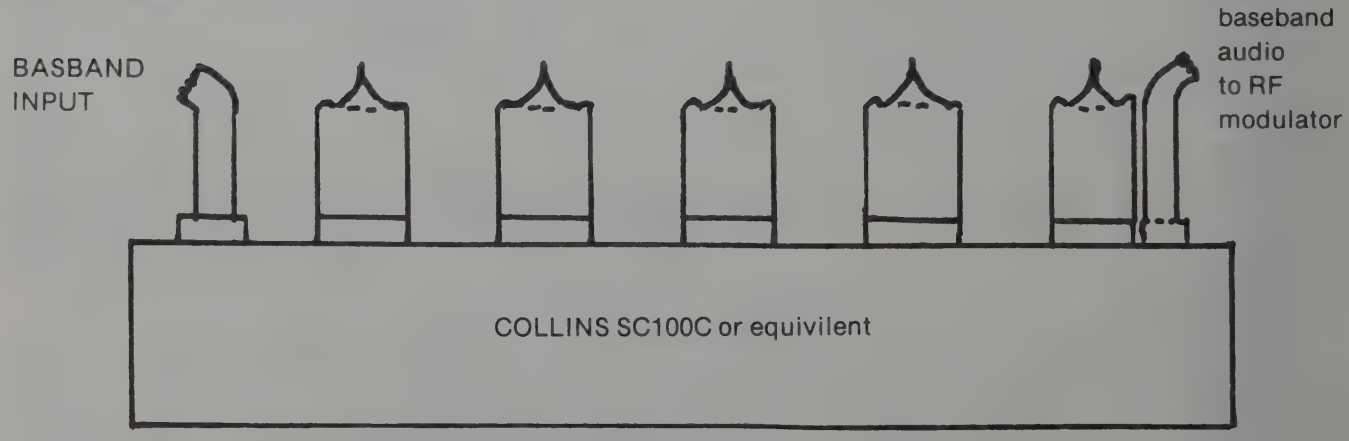
were taken out of terrestrial microwave service because they could not be bandwidth-broadened to cover the bandwidth required for video. There is a message here. If Telco took it out because they couldn't use it for video (i.e. this means that as a minimum for this application it needs to cover 60 to 80 MHz with a plus or minus 0.5 dB ripple maximum), chances are you can't make it work for satellite video either with satisfactory results. The Collins 22E2 series of solid state 70 MHz IF's which are now available on the market are a good example; the 2MW designation at the end (22E2-2MW) means it has the proper bandwidth modification for video. Some of these surplus strips can have their bandwidth's expanded (typically they are too narrow) through re-alignment; others will suffer low gain and/or excessive passband 'ripple' (i.e..gain variations beyond the recommended +/- 0.5 dB amount) after expansion.

Much of this equipment includes the discriminator (detector) on the same module. The 220A5 and the solid state 22E2-2MW are good examples. That means you kill two functions with one surplus module; you get adequate 70 MHz gain plus you get detected video (with the audio subcarrier contained with the video) out of the box.

Note: Although the 22E2-2MW is mentioned here, it is actually low in IF gain for this application. You can make up the gain required (it generally has about 30 dB) by increasing the amount of gain in the low noise pre-gain IF stage(s) by another 10 dB or so to make up for this shortcoming. Prices on the 22E2-2MW have generally been in the $25 to $30 range on the 'Hamfest' circuit and since you have a built-in discriminator as well, it is hard to pass up this type of bargain and then figure out how to make up the additional IF gain required later.

AURAL SUB-CARRIER DEMODULATOR

G



Aural Sub-carrier Demodulator Parameters

1) Ability to be (re) tuned to desired FM sub-carrier frequency (6.8 Mhz is standard SATCOM and ANIK sub-carrier; **some** WESTAR transponders employ 6.2 MHz and some of the newer RCA services on FII employ 5.5 MHz for digital audio and 7.4 MHz for special services)
2) Ability to discriminate + /- 75 KHz deviation material
3) Adequate output to drive RF re-modulator or local audio system (100 mW more than adequate for most purposes)

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There are other low cost options here. The CATV/MATV field offers many opportunities for low cost gain. CATV line extender amplifier modules, typically available for under $25 as 'surplus' device modules through local cable firms, have from 22 to 26 dB of gain. A pair of these will get you the gain you need, as the 'after-low-noise' (bulk gain) IF stages. However, CATV gear tends to be broadbanded gain. That is, the amplified pass band of such (CATV/MATV) modules covers at least 50/54 through 216/220 MHz. One of the reasons for the usefulness of the surplus 70 MHz IF strips is that these strips have reasonable 'skirt selectivity' beyond the desired passbands and that allows you to roll off (gain) on the adjacent (in frequency) satellite TV channels (transponders). If you elect to get your bulk gain with surplus CATV/MATV amplifiers, see The Howard Terminal Manual for a description of a 70 MHz (center) bandpass filter which should be employed at the input to the 70 MHz bulk gain stage to establish some IF selectivity in the system.

If the IF gain system you utilize does not have a built-in discriminator, see The Howard Terminal Manual for a description of a PLL discriminator system you can build up to detect the video present in the 70 MHz (center) IF passband.

THE AUDIO SUB-CARRIER DETECTOR

The audio for the satellite TV composite signal is carried on a sub-carrier. This sub-carrier stays with the video modulation information right through detection and it appears along with the video at the video (baseband) output 'spigot' of the discriminator. It turns into sound you can hear on headphones or through a speaker by going through a second detection process.

As shown in 'G' here, there are surplus units available which will or can be changed to detect the subcarrier audio. The Collins SC100C (tube type) unit was pressed into this service application by Coleman. When Coleman found it the unit was tuned to detect a sub-carrier signal at 5.5 MHz. Subcarrier demodulators have a tuned circuit in the input that is really nothing more than a narrow frequency range passband filter. This is usually preceded by a high pass filter; the high pass filter attenuates severely anything below say 4.5 or 5.0 MHz to keep the video modulation (baseband) products out of the subcarrier detection system. To change the operating frequency from whatever it arrives in your hands on to the proper satellite TV subcarrier frequency you have to retune the input end passband

COLLINS SC100C aural sub-carrier demodulator recovers 6.8 MHz audio for Coleman's system.

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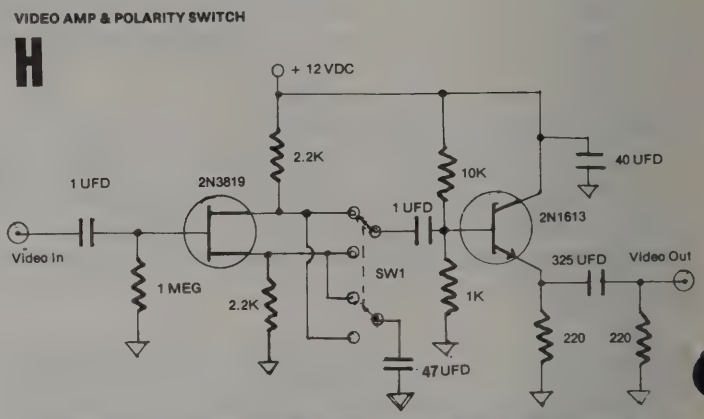
filter to either 6.8 MHz (the standard aural subcarrier frequency employed by virtually all of the SATCOM and most of the WESTAR channels) or to 6.2 MHz (the non-standard, second 'most popular' aural subcarrier frequency found on a few isolated SATCOM channels and on several of the WESTAR channels). This is simply a passband filter retuning job and if you know which direction you are going (up in frequency usually) you can treat the filter L/C networks accordingly (decrease the circuit inductance/capacity to go up in frequency, increase to come down). Once you have done that, you should be able to 'fine tune' it by ear by simply listening to the audio as you work with the input filter tuning adjustments.

The clamp. The uplink signal sent to the satellite is frequency 'dithered' or FMed by a 30 Hz waveform to 'disperse' the energy over a 1 MHz wide region. This is done to 'protect' terrestrial microwave systems by spreading the RF signal level out over a wider frequency range than it would normally occupy. Commercial receivers and The Howard Terminal Manual receiver get around this 30 Hz dithering waveform by inserting a 'clamping circuit' into the system. The usual place to insert this clamp is within the video amplification stage area. Commercial receiver clamping systems are elaborate and frankly overdesigned. Howard's receiver uses a single (fast) diode to clamp which acts to grab the sync tips and hold them to a level below where the frequency dithering can be seen. Another way to attain the clamping is to drive an amplifier stage into 'limiting'; accidentially or on purpose. You do this with an amplifier by driving it with so much signal that it turns into a limiter of sorts.



This portion of the system provides additional baseband (video) gain, and, it also provides a way (SW1) to reverse the polarity (negative and positive) of the TVRO video signal. When the local oscillator is tuned on the low side (satellite frequency **minus** 70 MHz), the polarity of the video goes in one direction. When the local oscillator is tuned on the high side (satellite frequency **plus** 70 MHz), the polarity of the video goes in the opposite direction. When tuning the LO (signal generator source), if a picture looks negative, simply switch SW1 and that corrects the polarity!

In the Coleman TD-2 conversion terminal this is how the 30 Hz waveform is handled; by having 100 dB of gain in the (Collins) 220A5 IF strip the latter stages end up 'limiting' (or clamping) the 30 Hz waveform. If you approach the IF strip in a different manner and you find you have an unstable video product coming out of the video spigot, you have to add a clamp. See the Howard Terminal Manual.

VIDEO AMP & POLARITY SWITCH

You may not have adequate video level coming out of your discriminator to drive your RF (re)modulator. Additionally, with a single conversion system (i.e. 4 GHz to 70 MHz IF in one conversion step) you will also find that you can place the local oscillator above or below the 4 GHz satellite signal and mix to 70 MHz. If you get

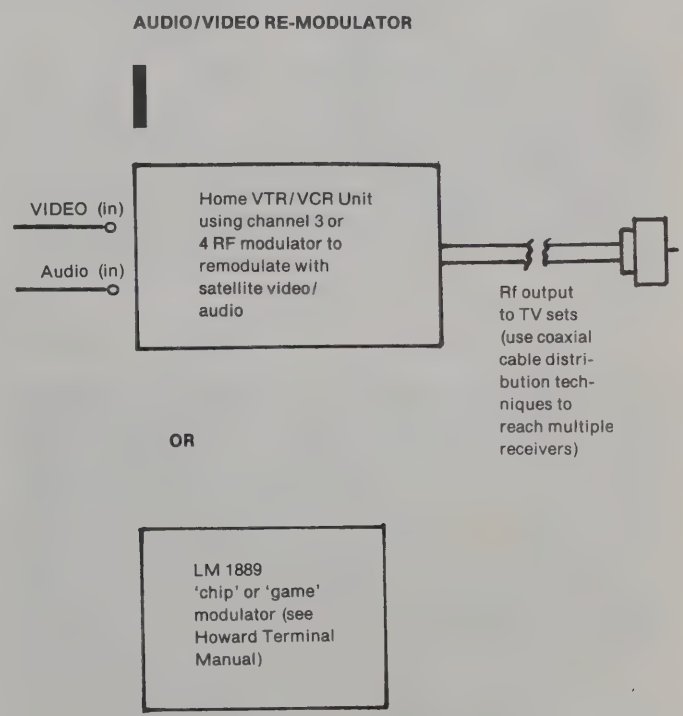
SHOWTIME AT COLEMAN TERMINAL - transponder 12.

the oscillator on one side of the carrier, the picture polarity will be positive; on the other side the picture polarity will be negative (i.e. blacks are white and whites are black). The easiest way around this problem is to install a simple 'video polarity switch' in the video amplifier. Thus the external video amplifier and polarity switch system shown in 'I' here. The video amp provides sufficent gain to drive an external RF (re) modulator and the polarity switch is hit the other way whenever in tuning around you find you've come up on 'the wrong side' of a satellite carrier and the picture is negative. The circuit shown is in use at the Coleman terminal and it may be constructed on a piece of G-10 board or even on perf board since we are dealing here with baseband and there is nothing critical about the way it is put together. House it in a mini box and you are in business!

THE RF (re) MODULATOR

Now we have the satellite TV signal down to baseband video and baseband audio. These two independent signals will drive a color TV monitor directly for fine (high quality) display of the satellite signal. However chances are if you have followed the 'cheap' route this far you want to be able to watch the pictures on a regular TV receiver. We do this by taking the baseband video and audio and using them to re-modulate an RF carrier in the standard NTSC format for direct cable connection reception on a standard (U.S.) television receiver.

There are several inexpensive ways to "re" modulate. If you already own a home VCR/VTR, you've got it solved. Simply take the baseband video and audio outputs from your TVRO receiver and loop the video line to the VCR video (camera) in and the audio line to the audio in. This turns your VCR internal RF channel modulator into a modulator for your TVRO. Turn on the VCR and simply run a piece of (RG-59/U) coaxial cable from the RF output terminal (an 'F' fitting) on the back of the VCR to the input terminal on your TV receiver. Tune the TV receiver to the proper TV channel (either channel 3 or 4 as selected by the channel modulator switch on the VCR) and you are in business.


AUDIO/VIDEO RE-MODULATOR
VIDEO (in)
Audio (in)
Home VTR/VCR Unit using channel 3 or 4 RF modulator to remodulate with satellite video/ audio
Rf output to TV sets (use coaxial cable distribution techniques to reach multiple receivers)
OR
LM 1889 'chip' or 'game' modulator (see Howard Terminal Manual)

If you do not have a home VCR, chances are you will eventually want one to videotape the fine satellite programs. In the interim however the National Semiconductor LM1889 'chip' is a complete 'modulator' for either channel 3 or 4 and it is available through numerous outlets advertising in major electronic magazines for $5 or less.

Yet another option is the 'Pixie Modulator (model PXP 4500 kit) available for $24.50 from: ATV Research, 13-B Broadway, Dakota City, Nb. 68731. There are a number of surplus items on the market that have NTSC standard TV 'modulators' in them, and finally The Howard Terminal Manual shows how to build an LM1889 type modulator from start to finish.

RF Re-Modulator Parameters

1) NTSC 6.0 MHz format (audio 4.5 MHz above video)

2) Baseband video (1 volt peak to peak), audio (0 dBm across 600 ohms typical) inputs

3) RF output on TV channel of choice (typically 3 or 4) with 1,000 (0 dBmV) to 10,000 (20 dBmV) microvolt level.

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Re-distributing at RF. Once you have the satellite signal remodulated to a VHF TV channel in a modulator, you can then connect up a fairly sizeable number of TV receivers to the system by stringing (burying, etc.) 75 ohm coaxial cable as a transmission medium. For runs of up to 500 feet or so type RG-59/U can be used. For longer runs to a single receiver or two up to 700 feet RG-11/U can be used. For still longer runs the aluminum sheathed cables such as type .412 can be used. This is basically how a cable TV (CATV) system operates. There are several techniques for connecting up multiple receivers; at any RADIO SHACK store you can purchase 75 ohm (hybrid) two way or four way signal 'splitters' which take the input signal (fed down the line from the RF modulator) and divide it up internally within the splitter to feed several TV sets at once. However for more elaborate systems signal 'tap off devices' are suggested; these are devices that extract a pre-determined amount of signal from the 'mainline' to the branch lines that connect to the individual TV sets. In this way receivers close to the modulator receive the same amount of signal as sets further down the line. For information and parts for this type of installation, contact DAVCO at P.O. Box 861, Batesville, Arkansas 72501.

THE LOCAL OSCILLATOR

Getting the 4 GHz range signal from its incoming frequency down to the much preferred 70 MHz IF frequency is a job for the TD-2 mixer (or a suitable substitute as outlined) and a local oscillator. The oscillator is a signal source. The mixer sees the two signals present, the TVRO input signal from the satellite and the local oscillator signal. It combines these two frequencies and produces a third frequency in the combining process; the IF which is in this case the difference between the local oscillator (LO) and the incoming TVRO channel signal. That difference is our 70 MHz signal.

The easiest LO to utilize is a surplus signal generator; such as the Hewlett Packard TS-403 found by Coleman at a Hamfest. You simply run a cable from the output of the signal generator to the LO input connection on the TD-2 mixer and tune the frequency control knob on the TS-403 and as you tune the signal generator through its range the output frequency varies and you in effect "tune through" the 3.7 to 4.2 GHz range in the downconversion process to your 70 MHz IF.

The TS-403 may be hard to find. But there are many other options and the TS-403 is not ideal in any case. As it sits, is does not tune the full frequency band

LOCAL OSCILLATOR SOURCE

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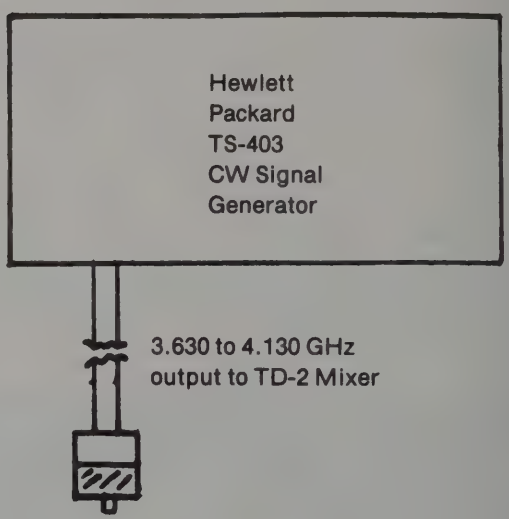


Local Oscillator Parameters

1) Resonable stability (drift of + /-5 MHz per hour is tolerable)

2) Reasonable purity (CW signal should be modulated by hum, etc. no more than 2%)

3) Reasonable levels of FM (no more than 2 MHz)

4(Output level of +6 to + 10 dBm

5) Frequency coverage from 3.63 up to 4.13 GHz. (**Note**: TS-403 typically covers low end OK but will not tune above 4.0 GHz which leaves satellite channels above 4.070 GHz out of tuning range; some versions of the TS-403 will, however, tune to 4.2 GHz.)

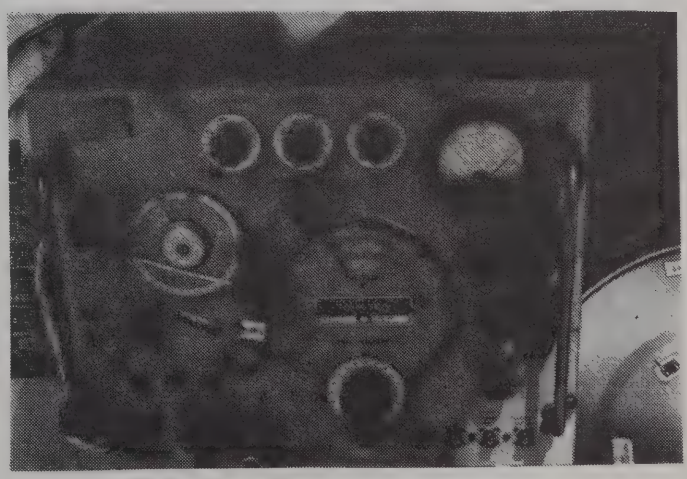
required; 3.630 GHz through 4.130 GHz. You determine the frequency band required by taking the satellite TV channel frequency and subtracting 70 MHz (the IF difference). Another version of the TS-403 does tune the full range however and Coleman reports that with a little prodding the TS-403 will tune to about 4070 or even 4100 MHz.

The general parameters in the surplus signal generator you are looking for are listed in 'J' here. You may not be able to determine just what the specs are if you locate a unit on the surplus market and will be lucky to know (with assurance) that the frequency range is as indicated.

The biggest single problem with most surplus-available microwave range signal generators is that they use an oscillator/amplifier device called a Klystron. These are typically very hard to find, out of date super high frequency tube type devices and if you get married to one in your system you can reasonably expect that sooner or later the Klystron will get weak, the output level (from the signal generator) will fall off (i.e. down) and the system will stop working. However inspite of this 'warning' it is an excellent way to get started for not very many dollars.

Long term you will want to graduate to a more state-of-the-art oscillator system. In The Howard Terminal Manual a solid state oscillator utilizing an Avantek VTO 8240 device is described. In the most recent Coleman terminal this VTO 8240 has been placed into service as a replacement for the TS 403 surplus signal generator. The VTO 8240 is very easy to operate (see The Howard Terminal Manual) and any home builder who would like to 'graduate' to this more sophisticated approach is advised to contact Coleman directly. Robert plans to have a VTO 8240 etched circuit board available shortly into which you can plug in the device, connect up a few wires, and be ready to go with a solid state signal source for your LO in your own terminal. The current pricing on the VTO 8240 is in the $115 region. Robert Coleman can be reached for more information on this adaptation and circuit board at: RFD 3, Box 58-A, Travelers Rest, S.C.

TUNING IT IN - tuning the surplus Hewlett Packard TS-403B/U (klystron driven) signal generator, as a tuneable local oscillator, allows Coleman to 'tune the full spectrum'.



SURPLUS IS BEAT UP — but it still works. HP signal generator.

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And this LO operating hint. If you are using a surplus signal generator, check to see if it has an 'output level control' on the machine. You will probably find that the best looking pictures are produced when the signal generator output is at the maximum level since most available are right at the ragged edge of having sufficent output for this application (typically +6 to +8 dBm is the best operating level for the mixer). If you happen to find a surplus signal generator that puts out more than +20 dBm, you will either have to go inside to bypass an output amplifier stage or use very loose (but adjustable) coupling to keep the level below the +20 dBm region. The TD-2 has a companion transmitter available on the surplus market. It has many useful component parts (such as the gold or silver plated feedthrough/bypass capacitors utilized in the LNA and shown on page 14) and in a pinch it could be pressed into service as an LO source but only on one (crystal controlled) frequency. If you decide to use the TD-2 transmitter as an LO source, be sure to bypass the final stage (it puts out several watts!) before coupling into the TD-2 receiver mixer head.

SURPLUS FOREVER - Robert Coleman puts his Heath capacitor checker to work checking out a couple of plastic bowls filled with miniature 'chipcapacitors' he found at a surplus sale. On the regular market these little jewels cost $5 or so. On the surplus market Coleman buys for pennies each.

QUICK BIRD REFERENCE

Satellite Name	Location (west longitude)	Number of Operating Channels	Typical Audio Subcarrier	Channel Format
SATCOM FI	135 degrees *	24	6.8 MHz	RCA
* - is expected to move west to 136 degrees after launch of FIII				
SATCOM FII	119 degrees	24	6.8 MHz	RCA
SATCOM FIII	132 degrees **	24	6.8 MHz	RCA
** - RCA will launch FIII between 1 October and 6 December 1979; all CATV traffic currently on F1 will shift to FIII at that time and FI will be used for expansion of (new) CATV programming services.				
WESTAR I	99 degrees	12	6.2, 6.8	Hughes
WESTAR II	123.5 degrees	12	6.2, 6.8	Hughes
WESTAR III	91 degrees ***	12	6.2, 6.8	Hughes
*** - WESTAR III scheduled for launch August 1979; is intended to carry 'broadcast television' relay services.				
COMSTAR I	128 degrees	24	5.5,6.2,6.8	RCA
COMSTAR II	95 degrees	24	5.5,6.2,6.8	RCA
COMSTAR III	87 degrees	24	5.5,6.2,6.8	RCA
NOTE: The FCC approved COMSTAR (owned by ATT & GT-E) relay of domestic video (television) programming as of July 23, 1979. It is anticipated that west coast (pacific and mountain time zones) NBC,CBS, and ABC network feeds plus non-network video programming will begin showing up on these satellites shortly.				
ANIK III	114 degrees	12	6.8 MHz	Hughes
ANIK B	109 degrees	12	6.8 MHz	Hughes

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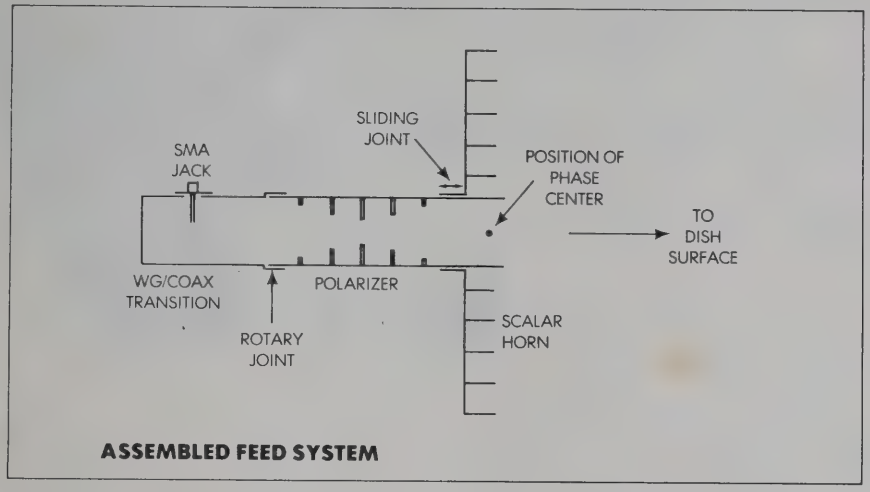
APPENDIX

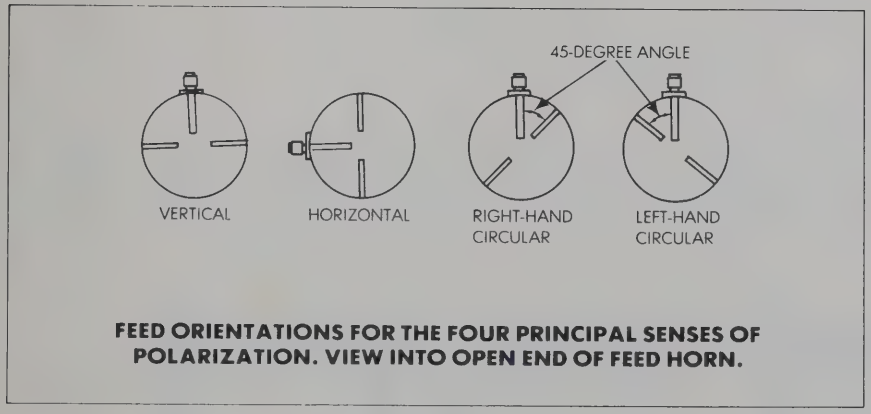
The following reference material may not be readily available to you. Material appeared originally in CATJ Magazine for February 1979 (Birkill Hybrid Mode Feed) and for July 1979 (two stage bi-polar LNA). For a complete copy of both articles write to: CATJ Magazine, Librarian Service, Suite 106, 4209 NW 23rd, Oklahoma City, Ok. 73107. Request:

1) Steve Birkill on Experimental Terminals / February enclosing $2.00 for Xerox copies,
2) Steve Birkill on Experimental Terminals / July enclosing $2.00 for Xerox copies.

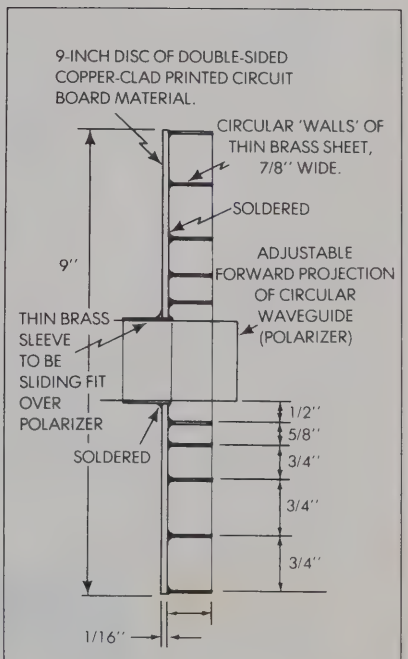
BIRKILL Hybrid Mode Feed Details:



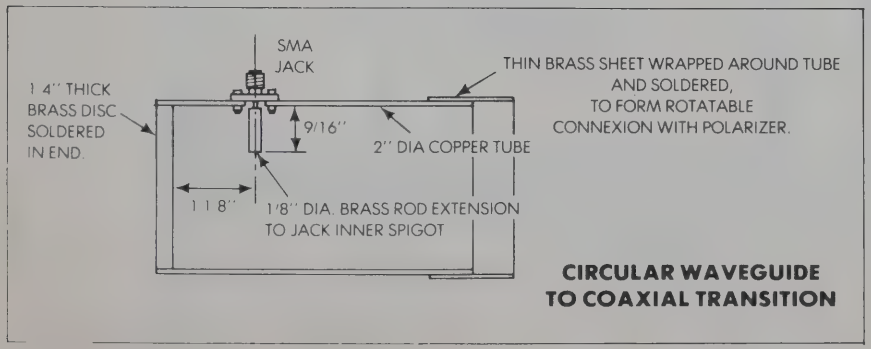
ASSEMBLED FEED SYSTEM



FEED ORIENTATIONS FOR THE FOUR PRINCIPAL SENSES OF POLARIZATION. VIEW INTO OPEN END OF FEED HORN.



SCALAR HORN


SMA JACK
THIN BRASS SHEET WRAPPED AROUND TUBE AND SOLDERED, TO FORM ROTATABLE CONNEXION WITH POLARIZER.
1/4" THICK BRASS DISC SOLDERED IN END.
9/16"
2" DIA COPPER TUBE
1 1 8"
1/8" DIA. BRASS ROD EXTENSION TO JACK INNER SPIGOT

CIRCULAR WAVEGUIDE TO COAXIAL TRANSITION

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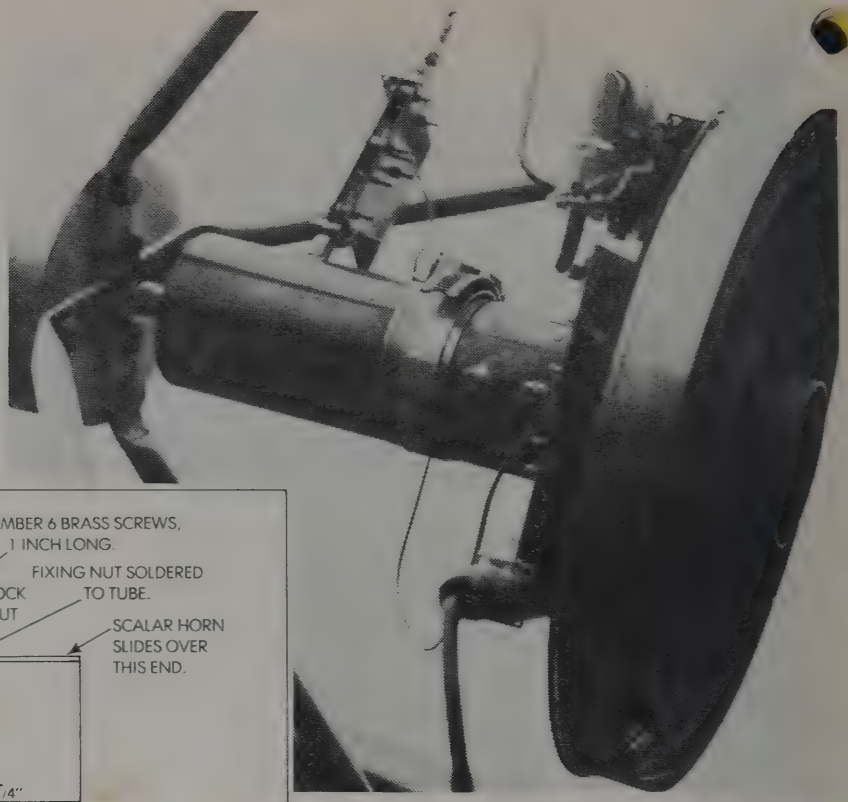
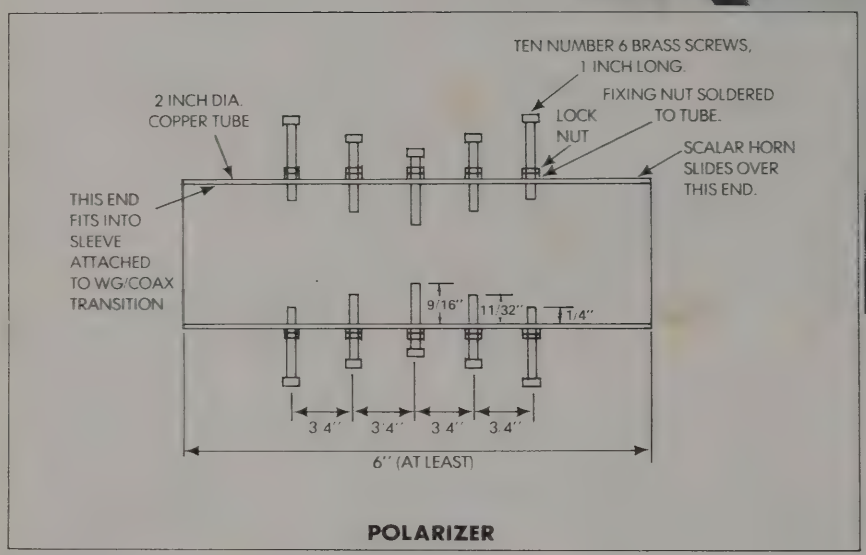
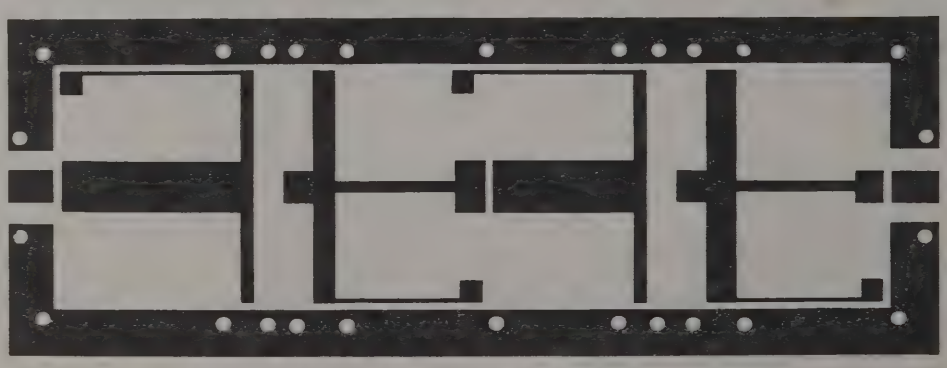




POLARIZER

BIRKILL Two Stage Bi-Polar LNA Details:

The following two-stage board has been laid out for the HXTR series (6101, 6102) bi-polar transistors from Hewlett Packard.Preceded by two stages of GaAs-FET LNA, it would make an excellent 'bulk gain' section for a four stage LNA system. See note page 17 about boards.



PATTERN FOR ETCHING UPPER SURFACE OF LNA MICROSTRIP BOARD.
LOWER SURFACE OF BOARD TO BE PLAIN COPPER.
THIS MAY BE REDUCED BY A FACTOR OF TWO FOR PHOTO-ETCHING.

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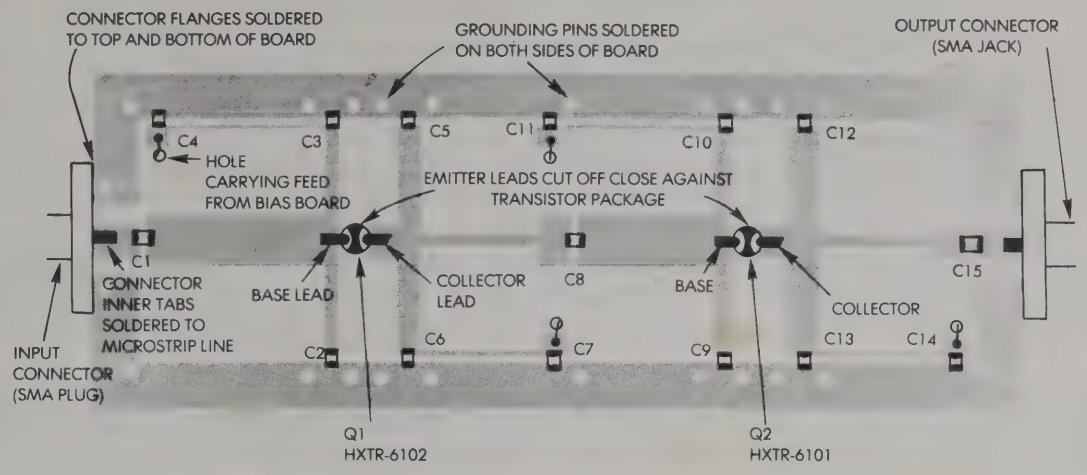
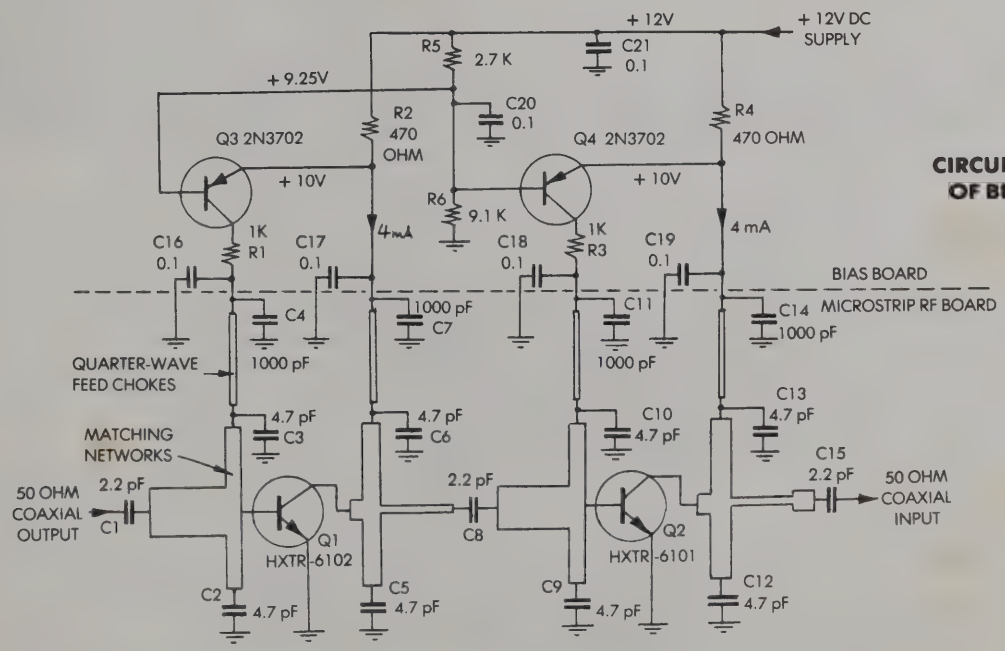
COMPONENT LAYOUT, TOP SIDE OF LNA RF BOARD



REDUCE TO 62.5mm



CIRCUIT SCHEMATIC OF BIPOLAR LNA

COMPONENTS LIST

Microstrip board: 62.5 x 22.5 x 0.79 mm Di-Clad 527, dielectric constant 2.5, etched

Transistors: Q1: HXTR-6102, Hewlett Packard
Q2: HXTR-6101, Hewlett Packard
Q3,4: 2N3702 or similar, Texas etc.

Resistors: 1/8 watt, metal film:
R1,3 - 1K 10%
R2,4 - 470 ohm, 5%
R5 - 2.7K 5%
R6 - 9.1K 5%

Capacitors: C1,8,15 - 2.2 pF, Vitramon VJ0805A2R2DF
C2,3,5,6,9,10,12,13 - 4.7 pF, Vitramon VJ0805A4R7DF
C4,7,11,14 - 1000 pF, Vitramon VJ0805X102KF
C16,17,18,19 - 0.1 microfarad, Vitramon VJ1808X104KF or low-voltage disc ceramic.

Connectors: Input SMA plug receptacle, tab contact, flush dielectric, Sealectro type 50-646-4575-31 (gold plated) or similar.
Output SMA jack receptacle, tab contact, flush dielectric, Sealectro type 50-645-4575-31 (gold plated) or similar.

Note: SMA connectors from different manufacturers may be known variously as SMA, SRM, RIM, or OSM

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SUPPORT MATERIALS

To produce this Coleman TD-2 Conversion Manual Bob Cooper spent two days with Robert Coleman at his Travelers Rest, S.C. home inspecting the Coleman terminal and its operation. During this visit a videotape was prepared for Coop's Satellite Magazine television program (seen on Transponder 21, 12 noon eastern, SATCOM FI every Thursday).

The Coleman TD-2 Conversion Videotape is available on either VHS or Beta format 1/2" cassette tape. Standard recording format is the 4 hour VHS (slow speed) and the 2 (or 3) hour Beta format. This videotape visit lasts about one hour in edited form, and takes you through the complete Coleman TD-2 conversion terminal showing you how each piece goes into the system and what is critical and not critical about the operation of the terminal. We believe that anyone who intends to duplicate the TD-2 conversion, or to attempt their own 'surplus' low cost terminal, will benefit from having this videotape study of the Coleman installation.

Additionally, during the Satellite Private Terminal Seminar (SPTS '79), held in Oklahoma City August 14-16 (1979) Robert Coleman appeared on the seminar program to describe his terminal design and his conversion techniques. A videotape, covering the appearance of Robert Coleman at SPTS '79, is also available; on the same 1/2" format speeds.

Finally, for those who have purchased this manual but not The Howard Terminal Manual from Satellite Television Technology, we suggest that this additional manual explaining how Taylor Howard designed a private terminal from scratch will be a valuable reference tool for you in collecting the materials to assemble your own private terminal.

Note: You do not have to use this order form. If you elect to not use this form, please be sure that all of the essential information asked for here is contained in your letter.

ORDER FORM - SUPPORT MATERIALS

___ $75 enclosed for VHS version of Coleman TD-2 Conversion Videotape
___ $70 enclosed for Beta version of Coleman TD-2 Conversion Videotape
___ $75 enclosed for VHS version of Coleman's Appearance at SPTS '79
___ $70 enclosed for Beta version of Coleman's Appearance at SPTS '79
___ $30 enclosed for The Howard Terminal Manual
___ $30 enclosed for Swan Spherical Antenna Manual

Total Enclosed - $_____

Ship to:

Name _____

Address _____

City/Town _____ State _____ Zip _____

Make check payable to: Satellite Television Technology
P.O. Box G
Arcadia, Ok. 73007

NOTE: California address appearing on bottom of pages is mail shipping depot only; all telephone queries should come to Arcadia office at (405) 396-2574.

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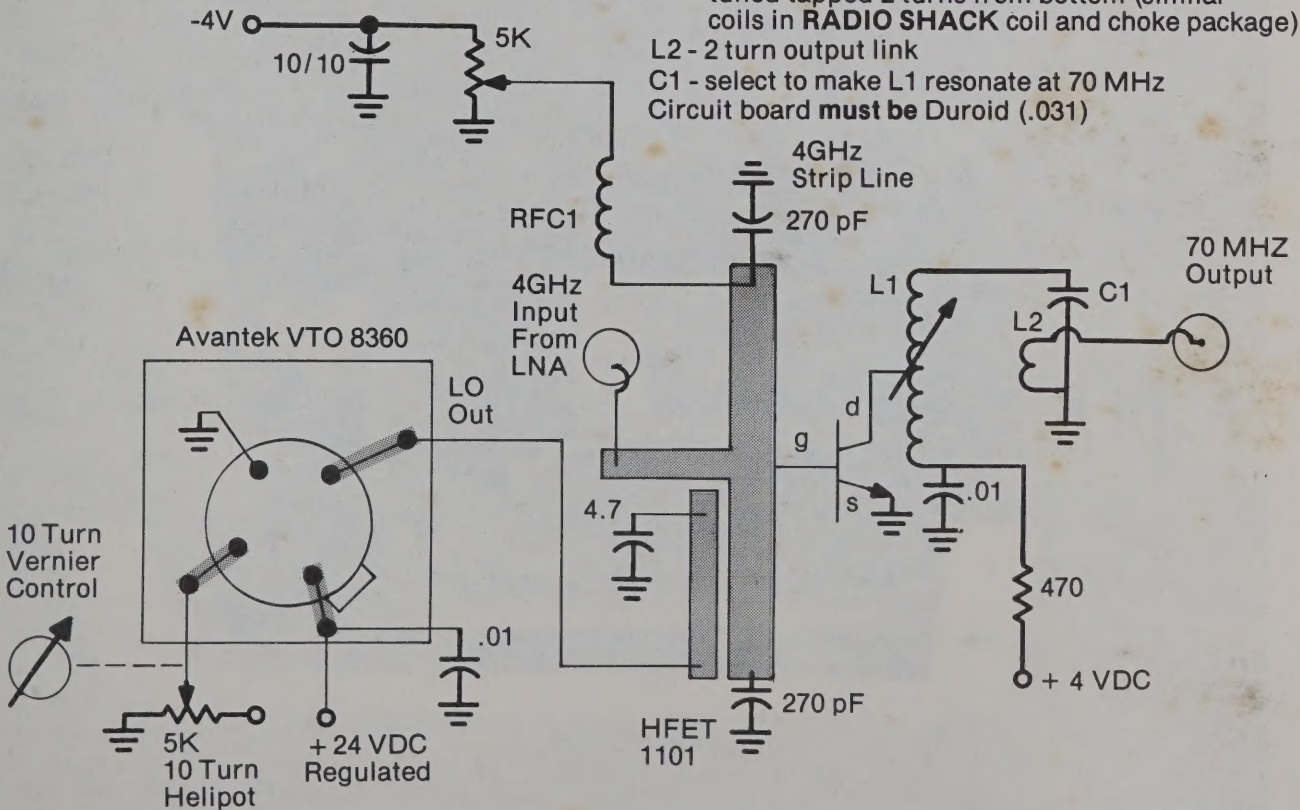
SUPPLEMENTAL DATA

In the interim since the original COLEMAN TD-2 CONVERSION manual was completed and distributed, Robert Coleman has created two additional pieces of 'hardware' which any serious builder should consider for his system.

One of the primary problems associated with the TD-2 approach (other than locating the TD-2 itself!) is also locating a suitable signal generator covering the 3.63 to 4.13 GHz range to use as a tuneable local oscillator. On page 34 here Coleman shows a state-of-the-art voltage tuneable oscillator (VTO) developed for his terminal. This system uses an AVANTEK model VTO 8360. This is a self contained VTO, you need only connect up the +15 to +24 VDC (regulated) operating voltage on pin 1 of the 8360, a circuit board ground to pin 3, and a stable but adjustable tuning positive voltage in the +10 to +20 VDC range to pin 2 for tuning purposes. Out of pin 4 you will derive an LO signal in the +10 dBm region to drive the TD-2 mixer.

If the TD-2 mixer is also difficult to locate, one option is of course to utilize the VARI-L DBM 500 mixer mentioned in the text of this manual. Another option with much improved operating characteristics is to build an "active mixer" using a single GaAs-FET device such as the Hewlett Packard HFET 1101. The circuit for this complete 4 GHz input and 70 MHz output system is shown below. A photo on page 34 shows the completed active mixer and VTO system.

COMBINING AVANTEK VTO 8360 AND HFET 1101 GaAs-FET FOR TUNEABLE 4 GHz TO 70 MHz DOWN CONVERTER USING ACTIVE MIXER



NOTES:

RFC! - 4 turns # 28 wire, 1/8'' diameter
L1 - 6 turns # 12 wire, 3/8'' diameter slug tuned tapped 2 turns from bottom (similar coils in **RADIO SHACK** coil and choke package)
L2 - 2 turn output link
C1 - select to make L1 resonate at 70 MHz
Circuit board **must be** Duroid (.031)

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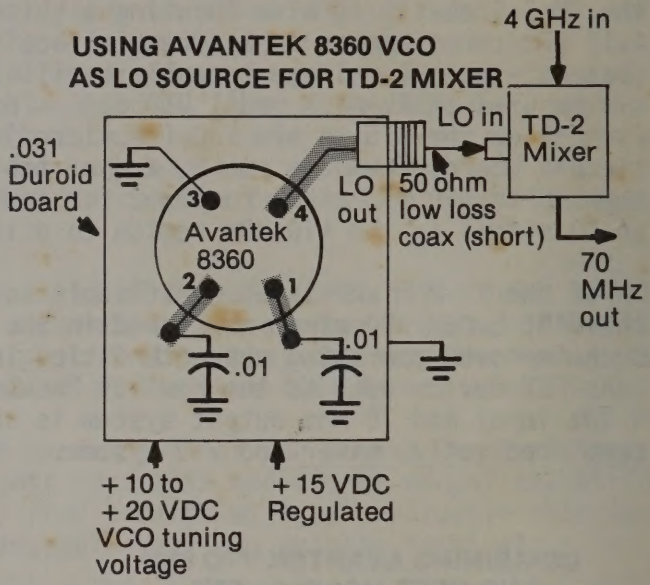
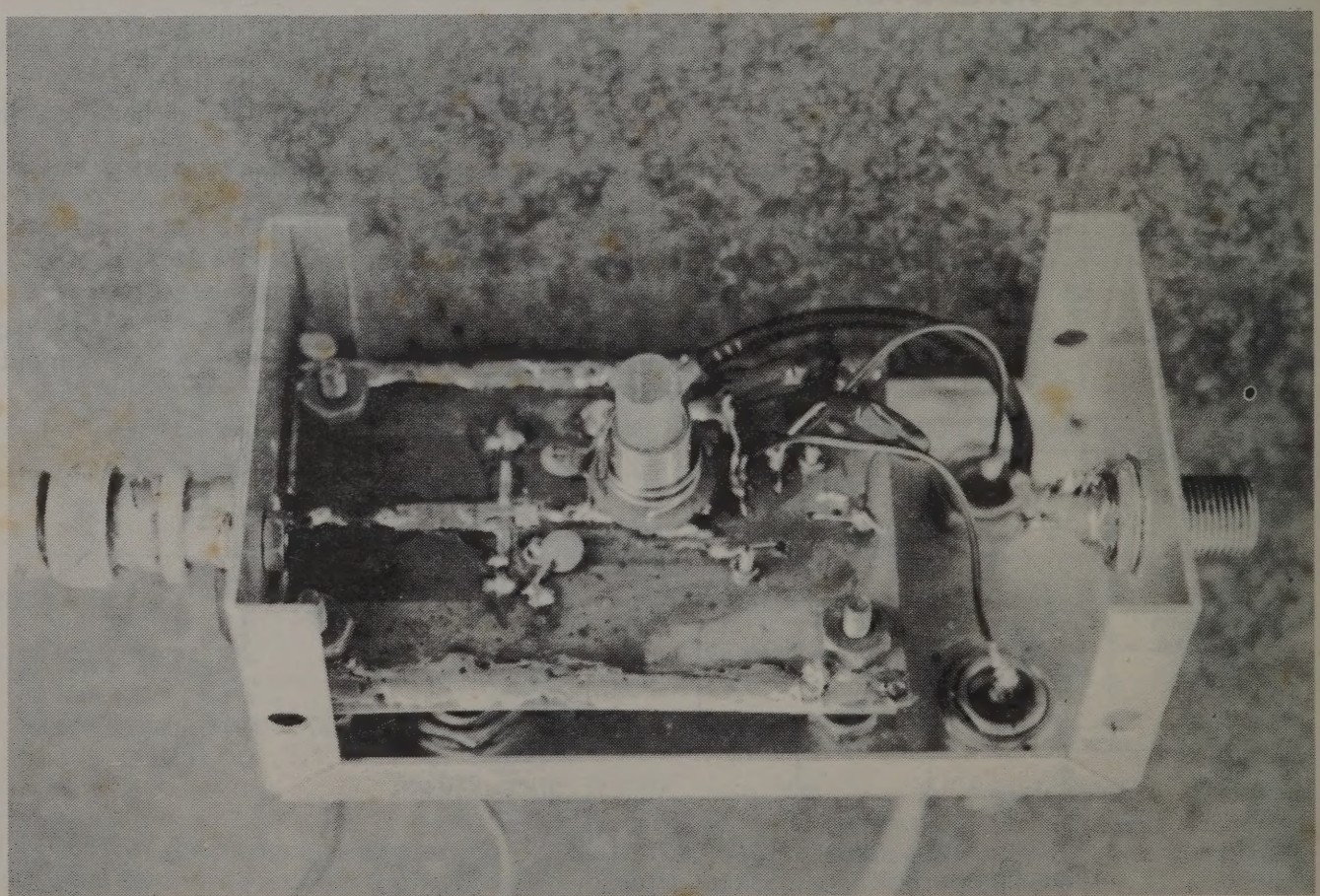
There is this warning. Never utilize an active mixer such as this, or a non double balanced (i.e. single ended) mixer without a minimum of one (and preferably two) stages of LNA between the 4 GHz mixer input and the feed of the antenna. The local oscillator source will couple back through the feed of the antenna to the reflector surface and can potentially cause very harmful interference to other 4 GHz receiving systems in the area.

Builders interested in exploring either the VTO 8360 as a local oscillator to drive a TD-2 (or VARI-L DBM 500) mixer, or interested in duplicating the HFET 1101 "active mixer" are encouraged to contact Robert M. Coleman directly.

Parts sources are: AVANTEK - 3175 Bowers Rd., Santa Clara, Ca. 95051; Hewlett Packard for the HFET-1101 - Hallmark Electronics Corp., 1208 Front Street, Bldg. K, Raleigh, N.C. 27609 (attention Paul Koeppen); the circuit boards from Robert M. Coleman, RFD 3, Box 58-A, Travelers Rest, S.C. 29690.





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